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Improving Frontline Supervision in Industrial Construction

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Improving Frontline Supervision in Industrial Construction

by

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Thesis

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Dedication

To the loving memory of my grandparents.

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As an Indian woman belonging to a conservative society, I am proud to be here today and grateful to my family who has helped me to reach this point. The decision to pursue Masters in the United States was never easy, and I thank my family and friends in India for their constant encouragement and undeterred belief. I would like to express my gratitude to my late grandparents, without whom I would not be who I am today.

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Finally, I would thank those who have supported me through my graduate studies through friendship and mentorship. I am thankful to everyone for making this journey very memorable and cherished. I would also extend recognition to my school Convent of Jesus and Mary, Ambala, my undergraduate university, National Institute of Technology, Kurukshetra, and Technip India Limited, especially to the people, for being a constant source of inspiration.

Abstract

Improving Frontline Supervision in Industrial Construction

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The University of Texas at Austin, 2017

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Frontline supervisors (Foremen and General Foremen) are the first line of supervision and are an important link between the management and their construction crew (Uwakweh 2005). They play a significant role in maintaining production on industrial capital projects where along with directly motivating and supervising their crew, and are responsible for a myriad of imperative yet time-consuming tasks during a typical work day. While many studies acknowledge the role of frontline supervisors especially foremen in supervising their crew, construction foremen are known as the marginal men in the industry and are comparatively understudied. Considering their role in maintaining production on industrial construction projects, the Construction Industry Institute (CII) sponsored the research titled "RT330- Improving Frontline Supervision in Industrial Construction". This research aimed to understand the role of frontline supervisors in Industrial construction. The efforts included identifying core competencies in productive frontline supervisors, defining an ideal productive day, identifying the effect of developmental training, analyzing the impediments to construction productivity as described by frontline supervisors, and recommending specific action items to the industry members including owners and

contractors. The research team identifies this effort as monumental, considering the number of frontline supervisors in industrial projects and the significant difference that is achievable if the performance of each supervisor in these fast track and complex industrial construction projects is improved even minutely. It is important to note that the scope of this thesis and the research study is limited to only heavy and light industrial projects. However, the recommendations and call to action might be equally applicable to other construction including commercial and heavy civil/infrastructure construction projects. This thesis contains the results of the efforts of the CII sponsored Research Team RT330.

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Chapter 1: Introduction

Frontline supervisors (Foremen and General Foremen) are the first line of supervision and are an important link between the management and their construction crew (Uwakweh 2005). They play a significant role in maintaining production on industrial capital projects where along with directly motivating and supervising their crew, and are responsible for a myriad of imperative yet time-consuming tasks during a typical work day. While many studies acknowledge the role of frontline supervisors especially foremen in supervising their crew, construction foremen are known as the marginal men in the industry and are comparatively understudied. Considering their role in maintaining production on industrial construction projects, the Construction Industry Institute (CII) sponsored the research titled "RT330- Improving Frontline Supervision in Industrial Construction". This research aimed to understand the role of frontline supervisors in Industrial construction. The efforts included identifying core competencies in productive frontline supervisors, defining an ideal productive day, identifying the effect of developmental training, analyzing the impediments to construction productivity as described by frontline supervisors, and recommending specific action items to the industry members including owners and contractors. The research team identifies this effort as monumental, considering the number of frontline supervisors in industrial projects and the significant difference that is achievable if the performance of each supervisor in these fast track and complex industrial construction projects is improved even minutely. It is important to note that the scope of this thesis and the research study is limited to only heavy and light

industrial projects. However, the recommendations and call to action might be equally applicable to other construction including commercial and heavy civil/infrastructure construction projects. This thesis contains the results of the efforts of the CII sponsored Research Team RT330.

Several studies recognize the importance of construction foremen in motivating workers, assuring safety and quality, and efficiently conducting work (Senior 1996). Other studies have established the importance and their role as a crucial link between the management and workforce (Uwakweh 2005). Where their duties include a myriad of responsibilities including managing, planning and defining work, communicating with workers, and motivating them to perform at acceptable levels. It becomes imperative for the industry to understand their roles and responsibilities, especially in complex and fast paced industrial construction projects. The need to increase predictability and performance in industrial projects reinforces the fact that in the industrial sector 70 % of the projects exceeded 10 % variation from the expected schedule and cost values (Choo et al. 1999). Considering the dynamics of production and external impediments and the vital role played by foremen in increasing construction productivity and maintaining performance, this research has aimed to provide specific recommendations to the industry including ensuring developmental training for their frontline supervisors.

The first part of this research study aimed at identifying the core competencies in productive frontline supervisors. Previous studies have recognized the importance of identifying the core competencies in frontline supervision to increase construction productivity and importance. Uwakweh acknowledged that identifying core competencies

in frontline supervisors is important to increase construction productivity and performance (Uwakweh 2005). The preliminary work of Construction Industry Institute in establishing critical supervisory behaviors and the prerequisite knowledge, skills, abilities, and personality traits of supervisors has been the basis of this research study to extensively study the core competencies and measure the performance of frontline supervisors in North America. The researchers of the study themselves recognize that since the research was conducted in the 1990s, the scope of recommendations might be limited beyond the 1990s.

Studies to identify characteristics of productive industrial foremen and how they perceive or perform their jobs differently and their influence on performance have been done in the past (Lemna et al. 1986; Uwakweh 2005; Maloney and McFillen 1987). Shohet and Laufer identified that despite the acknowledged role of foremen in the execution of construction projects, their function had received less importance. They studied the behavioral patterns of construction foremen and their influence on construction productivity. They concluded that the role of a foreman as a manager or supervisor is very important and they can effectively replace replanning with pre-planning to increase construction performance and productivity (Shohet and Laufer 1991).

Studies that identify the importance of supervisory skills and competencies and the urgent need of their training were conducted in the past. Hewage et al. researched on-site construction professionals in Alberta building construction projects and identified weak supervisory skills of foremen and the urgent need of training programs for field managers to improve their present skill levels (Hewage et al. 2011). Rojas provided a 360º assessment of field supervisors and project managers within an unionized electrical contracting

company and identified 12 pillars of successful supervision (Rojas 2013). Further, a competency-based model to analyze the role of construction site supervisors, including Foremen and General Foremen, has been developed to train, develop, and certify construction supervisors in Chile and other developing countries (Serpell and Ferrada 2007). However, the authors themselves recognized that the results of the study apply to only developing countries of that region (Serpell and Ferrada 2007). Dainty et al. presented a competency-based model for predicting the performance of construction project managers to facilitate their recruitment and performance management (Dainty et al. 2005). Fuzzy logic has also been used to predict and evaluate construction trades foremen performance with specific applications in evaluating performance, factors that affect their performance on a daily basis and also includes efforts to benchmark their performance (Poveda and Fayek 2009)

All the above studies have provided evidence to the importance of frontline supervisors in maintaining construction productivity and performance in industrial construction projects. Along with establishing their importance and acknowledging their role, they have also ascertained the importance of defining core competencies in productive frontline supervisors. However, the research team believes that they have not received much importance with regards to the investment in training and developmental programs by the contractors for which they work. The RT330 research team is composed of 18 industry representatives who have extensive construction experience and believe that improving frontline supervision in industrial construction is imperative to increase construction productivity and performance. There is enough testimony to the fact that

construction productivity is on a steady decline in the past decades and there is an urgent need that the industry develops and trains their frontline supervisors. The core competencies would help the industry in developing training programs which would be an important step in recruiting, training, and retaining the pool of talented and competitive frontline supervisors. The research hypothesis is that frontline supervisors in industrial construction projects lack the desired skills and competencies to increase construction productivity and performance. This thesis addresses the first research question in Chapter 2 of this thesis. "*What are the core competencies in frontline supervisors in industrial construction projects? What is their current level in the industry and what are the key areas that pose a challenge and have potential room for improvement?*"

The second part of this research aimed at identifying the key tasks undertaken by Foremen and General Foremen on industrial construction projects. Along with identifying key tasks and their corresponding ideal time ranges, this research surveyed frontline supervisors in North America to report the key areas in which they were spending their time. Other studies have recognized the influence of frontline supervisors in supervising and motivating workers in influencing construction productivity. They have also established a correlation between the time spent by a foreman during a workday with the performance of their crews. Argyle et al. investigated the effects of different styles of first-line supervision on productivity (Argyle et al. 1957). Hinze and Kuechenmeister investigated the characteristics and common traits of productive industrial foremen (Hinze and Kuechenmeister 1981). Lemna et al. identified characteristics of industrial foremen and their effect on construction productivity (Lemna et al. 1986). Maloney and McFillen

identified five dimensions of foremen performance and their relationships with worker motivation, performance, and satisfaction (Maloney and McFillen 1987). Shohet and Laufer identified the correlation of foremen time spent during a workday with the performance of their crews (Shohet and Laufer 1991). Senior elaborated on foremen planning behind short-term task scheduling (Senior 1996). Uwakweh identified seven foremen scales to establish their relationship with the motivation and performance of construction apprentices (Uwakweh 2005).

These studies have established where frontline supervisors especially foremen spend their time on a typical workday, however, do not granulize the tasks and enable the frontline supervisors to self-report where they are spending their time. The RT330 research team believes that identifying key tasks along with analyzing the areas where frontline supervisors which have room for improvement are very helpful for the industry to improve frontline supervision in industrial construction. The second research question that follows from this is "*What are key tasks that a productive frontline supervisor undertakes during a day at an industrial construction site? Which key areas indicate room for improvement?*"

The third part of the research aims at understanding the influence of productivity enhancing practices including Advanced Work Packaging and AWP developmental training on the performance of industrial frontline supervisors. Productivity Enhancing practices including Advanced Work Packaging have been observed to increase performance and productivity on Industrial Construction Projects. CII RT272 defines AWP as a disciplined approach to improving productivity and predictability by aligning planning and execution activities across the project life cycle, from project setup to start up and

turnover (Construction Industry Institute 2013a). The background literature on AWP establishes how AWP aimed towards improving productivity on industrial construction projects in Alberta oil sands construction projects. Some of the steps included delivering all resources necessary at the right time, to the right place, and to the right people to execute construction, to avoid cost overruns and delays. Other steps including relieving the onsite supervision team from the time-consuming tasks of onsite planning and resource tracking; thereby allowing them to focus on production and direction of their crews. These two measures explain that AWP helps in increasing construction productivity by active pre-planning and reducing external impediments to production. Figure 1 below explains in detail the concept behind AWP and how does it include active pre-planning right from the initial stages of an industrial construction project.

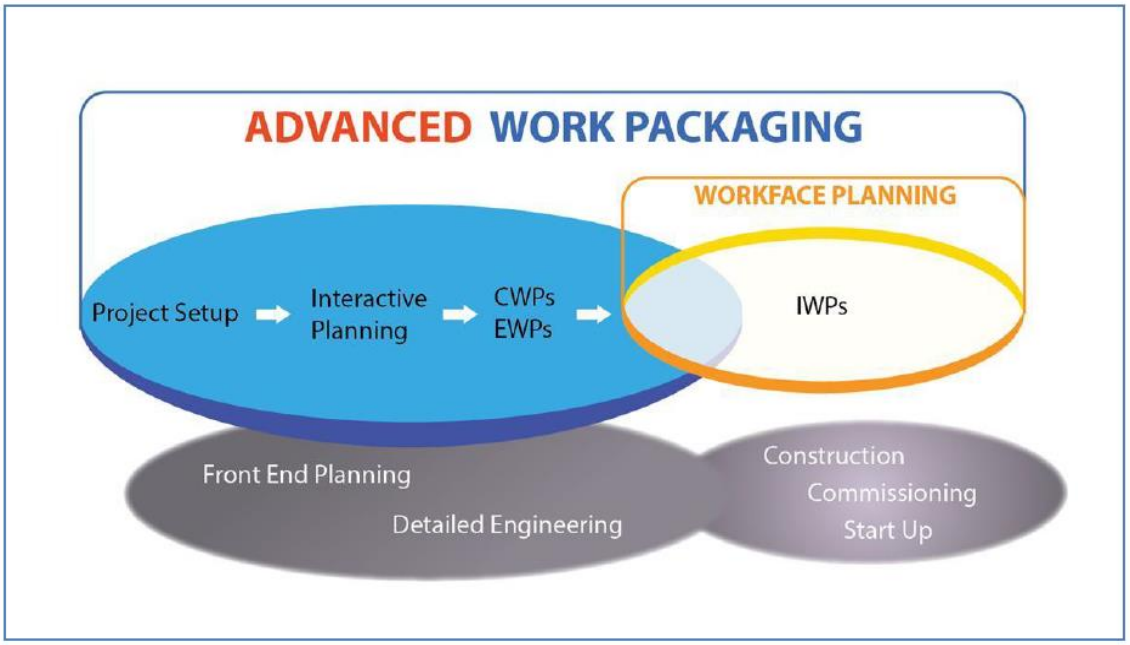


Figure 1 Concept of Advanced Work Packaging; Source: Construction Industry Institute: Advanced Work Packaging: Design through Workface Execution, Research Summary RT272-1, Version 2.1 (Construction Industry Institute 2013b)

Development training programs enable frontline supervisors to boost core competencies to enhance their productivity and performance. Goodrum et al. suggested that formal training lowers the cognitive load on workers and potentially improves their performance (Goodrum et al. 2016). Kumaraswamy illustrated the importance of integrated training programs to uplift the knowledge, skills, the attitude of construction workers and managers (Kumaraswamy 1997). Serpell and Ferrada proposed a labor competency management framework to train, develop, and certify construction supervisors in Chile and other developing countries (Serpell and Ferrada 2007). Maloney and McFillen suggested that journeymen are made foremen with little or no supervisory training and hence concentrate on their craft and not supervising and motivating their crew (Maloney and

McFillen 1987). Fayek et al. identify the importance of front-line supervisors in the labor-intensive construction industry and the need for supervisory training to effectively undertake their responsibilities (Fayek et al. 2006). These studies establish the importance of developmental training in ensuring that frontline supervisors effectively perform their responsibilities in labor intensive and dynamic construction environments.

These studies establish the importance of developmental and supervisory training, however, do not provide any granular comparisons between the performance of frontline supervisors with and without any formal training. For this research, comparison of time spent by frontline supervisors in traditional and AWP projects and those with and without AWP training is used to demonstrate the importance of productivity enhancing practices, in particular, Advanced Work Packaging, AWP in increasing performance on Industrial construction projects. The third research question that follows is "*Is there a difference in the time spent by frontline supervisors in traditional and AWP work environments? What is the influence of developmental training, in particular, AWP training on the performance of frontline supervisors in industrial construction projects*?".

Before elaborating on the research questions defined in this section, it is important to define the various terms used in this thesis. It is necessary to establish these terms and industry definitions along with defining the scope of our research. This section provides definitions of terms including Foremen, General Foremen, and Superintendents for the scope of this research. These terms apply to heavy and light industrial construction projects and might change with the type of construction environment. The terms Frontline

Supervisors and Foremen and General Foremen would be used interchangeably in this thesis.

General Foreman (GF): GF is the top level of frontline supervision and usually supervises 3-6 Foremen (F), typically within a specific craft or discipline. Main responsibilities of a GF include planning for production several days in advance, the typical duration being three weeks, ensuring that his F have the necessary resources including equipment, material, scaffolding, cranes, etc. Additionally, they help in assessing completed progress and forecasting future labor needs.

Foreman (F): Foremen are a crucial link between management and the crew. They are responsible for supervising and motivating the crew. Typically, Foremen have 8-12 craftsmen in the crew. Their immediate responsibilities include making sure that his crew is productive, safe, and performs quality work. In some jobs, foremen act as working foremen or leadmen especially when the crew is small.

Superintendent: Superintendents are the top level of supervision for a specific craft or area of work and accordingly addressed as a craft or general superintendent. Typically superintendents supervise a crew of 3-5 General Foremen. Their main responsibilities include safe and productive execution of work. The next section would provide details on previous studies on frontline supervisors to establish the importance of this research and to define the scope.

This thesis consists of a total of six chapters covering each of the areas described above in detail. Chapter 1 provides a detailed explanation of the past studies on frontline supervisors. It also defines the research hypotheses and essential research questions. Along

with establishing the importance of studying ways to improve frontline supervision in industrial construction, it presents the past studies on Frontline supervisors and their importance in defining the hypothesis of this study. It also captures the definitions of Foremen, General Foremen, and other terms used significantly in the thesis.

Chapter 2 elaborates on the core competencies in productive frontline supervisors as identified by the research team. Along with establishing the core competencies based on previous research studies and a Delphi approach within the industry expert members of the research team, this chapter establishes their importance with the help of electronic surveys distributed to superintendents and managers with craft knowledge within North America. This chapter established the ten competencies and discusses the survey results which reinforce the pressing need for the industry to invest in frontline supervisors.

Chapter 3 defines the ideal productive day for both foremen and general foremen on industrial construction projects. Along with establishing ten and eight crucial tasks during a productive day for foremen and general foremen respectively, this chapter illustrates the different categories in which the frontline supervisors self-report the time spent when asked on industrial sites within North America. Along with elaborating on the time spent by the frontline supervisors on all the projects covered during the study, a separate analysis is done for specific crafts and different production productivity programs. The three different production programs in this chapter are traditional, maintenance, and Advanced Work Packaging/Workface Planning programs. This chapter is important to highlight the differences between the proposed time ranges in which a frontline supervisor should spend their time and actual industry practices. The difference between the proposed

ideal day and actual time spent is used to explain the importance of addressing the problems faced by frontline supervisors including their competencies and skills and the external impediments faced.

Chapter 4 further elaborates on the productivity impediments covered in Chapter 3. It establishes six workforce/planning related impediments and five field related impediments. Based on the responses from surveys across North America, the overall score of each of the impediments based on a five-point Likert scale is used to explain the external impediments to production faced by frontline supervisors on industrial projects. Further, a comparison of production impediments in the two production programs including traditional and AWP/WFP environments is presented to suggest ways improve the performance of the frontline supervisors.

Chapter 5 explains the importance of AWP and developmental training in improving the performance of frontline supervisors. Along with comparing the time spent in each of the eight and ten categories for General Foremen and Foremen respectively for those who received AWP training or not, this chapter further compares the time spent by frontline supervisors on traditional and AWP projects. The recommendations presented in this chapter is specific to the industry members to adopt productivity enhancing practices especially Advanced Work Packaging to improve the performance of frontline supervisors.

Chapter 6 is the concluding chapter that provides consolidated results and discusses the importance of this study in academic research. Overall this thesis describes in detail the role of frontline supervision in industrial construction. Along with understanding the role it aims at improving the frontline supervision. The thesis aims at identifying core

competencies in productive frontline supervisors along with identifying crucial tasks and their proposed ideal time ranges as proposed by the Research Team. This research further explains the importance of productivity enhancing practices including Advanced Work Packaging (AWP) in increasing productivity by effectively shielding production from external impediments. It also researches on the effect of developmental training including AWP training on the performance of frontline supervisors. The research team believes that with specific recommendations for both owners, contractors, and for academic practitioners, this research would be monumental in improving the frontline supervision in industrial construction.

Chapter 2: Core competencies in productive Foremen and General Foremen: Identification and need for improvement

SUMMARY

Frontline supervisors (Foremen (F) and General Foremen (GF)) have a significant impact on the productivity, quality, and safety of an industrial construction project. This chapter focuses on identifying the desired skills and competencies in productive frontline supervisors in industrial construction, assessment of importance to productivity by superintendents and related personnel, and finally an assessment of the current skill level of frontline supervisors by the same population of superintendents and related personnel. It explains the methodology in finalizing the ten core competencies and substantiates the findings with appropriate statistical analysis of data from industrial construction sites in North America (The US and Canada). The ten core competencies described in this chapter are general construction knowledge, trade specific knowledge, verbal communication, written communication, pre-planning, problem-solving, ethical value system, people management, leadership, and proactive and goal driven. The principal findings include that the core competencies are different on the importance in construction performance for both Foremen and General Foremen. Three competencies including written communication, pre-planning, and problem-solving indicate areas that need improvement for both Foremen and General Foremen. The current competency level shows the need for improvement, especially for Foremen. Overall the mean score of the competencies for General Foremen is more than that for Foremen. Identification and assessment of current competencies are very important to improve the performance of industrial construction frontline supervisors.

INTRODUCTION

The importance of construction foremen in motivating workers, assuring safety and quality, and efficiently conducting work has been recognized in several studies (Senior 1996). They are a crucial link between the management and workforce (Uwakweh 2005). They are expected to manage, plan and define work, communicate with workers, and motivate them to perform at acceptable levels (Uwakweh 2005). Their performance has a significant impact on the cost and schedule of industrial capital construction projects. The dynamic and complex nature of these projects intensifies the cognitive load and responsibilities on frontline supervisors. The need to increase predictability and performance of industrial construction projects is reinforced by the fact that in the industrial sector 70 % of the projects exceeded 10 % variation from the expected schedule and cost values (Choo et al. 1999). Both the owner and contractor organizations should undertake unified efforts to effectively train their frontline supervisors to pursue their responsibilities crucial for maintaining performance in industrial construction.

However, the transient nature of industrial construction foremen makes it difficult for contractors to justify the cost of investment in developmental training. The construction General Foremen are however not a transient workforce. The research team believes that most contractors continue to select their new foremen from an assortment of the “best” of an increasingly inexperienced labor craft labor pool, based on recommendations by their General Foremen and Superintendents. These Foremen assume their new roles, with minimal onboarding support and rely on daily guidance from their peers and supervisors to help them transition into their new responsibilities. Typically, over time, these

individuals either succeed or fail through their efforts and work opportunities with a variety of companies, with different cultures and different support structures. Some continue as Foremen; some fall back to working with their tools and a few advance to the General Foreman level. Very few are ever formally evaluated to determine their strengths and weaknesses, and even fewer undergo training and developmental opportunities that they need to reach their full performance potential. The result is that most Foremen and General Foremen are never given their best opportunity to do well, and consequently the performance of craft labor on many projects is much less than optimal.

The purpose of this research is to offer an advantage to the organizations to benchmark the skills and competencies to recruit effectively, train, and retain productive frontline supervisors. In industrial capital construction projects, it is also important to establish the current capabilities and skill sets of frontline supervisors. A comparison of the current and desired skills would establish a framework to predict and strengthen the competencies of on-job frontline supervisors in crucial industrial capital construction projects.

This chapter defines the ten core competencies in productive frontline supervisors in industrial construction projects. It establishes the results with the help of a two-step approach. It firstly establishes that the ten proposed competencies are important to maintain production for both foremen and general foremen. Secondly, demonstrates that the skills are weak in both foremen and general foremen. The ten core competencies as identified by the research team are general construction knowledge, trade specific knowledge, verbal communication, written communication, pre-planning, problem-solving, ethical value

system, people management, leadership, and proactive and goal driven. The principal findings include that the core competencies are different on the importance in construction performance for both F and GF. Three competencies including written communication, pre-planning, and problem-solving indicate areas that need improvement for both Foremen and General Foremen. The current competency level shows the need for improvement, especially for Foremen. Overall the mean score of the competencies for General Foremen is more than that for Foremen. Identification and assessment of current competencies are very important to improve the performance of industrial construction frontline supervisors.

LITERATURE REVIEW

Identifying core competencies in frontline supervisors is important to increase construction productivity and performance (Uwakweh 2005). However, their evaluation is a research area that is relatively understudied. The Construction Industry Institute's research titled "A framework for continuing supervisory education" identified critical supervisory behaviors and their prerequisite knowledge, skills, abilities, and personality traits which it collectively referred to as competencies. Lemna et al. acknowledged that the results of the study might not be applicable beyond the 1990s (Gary J. Lemna et al. 1986). Studies to identify characteristics of productive industrial foremen and how they perceive or perform their jobs differently and their influence on performance are done in the past (Lemna et al. 1986; Uwakweh 2005; Maloney and McFillen 1987). Shohet and Laufer identified that despite the acknowledged role of foremen in the execution of construction projects, their function had received less importance. They studied the behavioral patterns of construction foremen and their influence on construction

productivity. They concluded that the role of a foreman as a manager or supervisor is very important and they can effectively replace replanning with pre-planning to increase construction performance and productivity (Shohet and Laufer 1991).

Past Studies have identified the importance of supervisory skills and competencies and the urgent need of their training. Hewage et al. researched on-site construction professionals in Alberta building construction projects and identified weak supervisory skills of foremen and the urgent need of training programs for field managers to improve their present skill levels (Hewage et al. 2011). Rojas provided a 360º assessment of field supervisors and project managers within an unionized electrical contracting company and identified 12 pillars of successful supervision (Rojas 2013). Further, a competency-based model to analyze the role of construction site supervisors, including Foremen and General Foremen, has been developed to train, develop, and certify construction supervisors in Chile and other developing countries (Serpell and Ferrada 2007). However, the authors themselves recognized that the results of the study apply to only developing countries of that region (Serpell and Ferrada 2007). Dainty et al. presented a competency-based model for predicting the performance of construction project managers to facilitate their recruitment and performance management (Dainty et al. 2005). Fuzzy logic has also been used to predict and evaluate construction trades foremen performance with specific applications in evaluating performance, factors that affect their performance on a daily basis and also includes efforts to benchmark their performance (Poveda and Fayek 2009). All these studies have realized the importance of identifying core competencies in frontline supervisors. However, this research identifies ten core competencies and also signifies the

industry gap and room for improvement by conducting a country-wide survey of superintendents and managers with craft knowledge.

Overall, frontline supervisors have been under-studied in the past. Less research is available on General Foremen in comparison to Foremen. The research team deemed necessary to identify and compare core competencies of productive frontline supervisors, both Foremen and General Foremen.

RESEARCH QUESTIONS

Based on the literature review, for most of the research studies are either dated or do not consider frontline supervisors in their scope. Lemna et al. acknowledged that the results might not be applicable beyond the 1990s (Lemna et al. 1986). Serpell and Ferrada acknowledged that the research study is applicable developing economies with a large construction workforce (Serpell and Ferrada 2007). Other studies cover limited scope and do not dwelve deeper into the competencies and cureent competency level in the industry. Considering the limited availability of resources and past research studies to define core competencies in productive frontline supervisors, RT330 concentrated on identifying and defining the core competencies along with measuring the current industry levels. The two research questions addressed in this chapter are: What are the skills and competencies of General Foremen/Foremen in capital construction projects?; What are the current capabilities and skill sets of industrial General Foremen and Foremen and what is the gap?

RESEARCH METHODOLOGY

The research team started with reviewing the existing literature and determining the list of competencies which applied to industrial frontline supervisors. The available

literature reinforced that limited or dated research is available on frontline supervisors especially on their competencies. After a detailed evaluation of previous CII sponsored research studies and inputs from the industry representatives, the research team narrowed down to a list of ten competencies from about nearly a hundred and fifty. The ten competencies were deemed to be equally important for both Foremen and General Foremen. After the research team had finalized the competencies, they defined the scope of tasks and responsibilities covered under each of the ten categories. After clearly defining the scope, the next step involved evaluating the competencies. The research team surveyed a group of superintendents and managers with craft knowledge to report their understanding of two important aspects. The respondents were asked their opinion on the importance and current level of competencies in their frontline supervisors on industrial construction projects. It helped the research team to validate the research hypothesis that the identified list of competencies is important and also there is a lot of room for improvement. The electronic survey was created in an Online Survey platform known as Qualtrics Survey Tool. The Survey is available in Appendix 1 of this thesis. The data collection started in the summer of 2016. The surveys received were analyzed statistically to summarize the results. A detailed list of competencies along with an industry survey helps to identify the areas which need improvement and are helpful to determine training guidelines that should be adopted in the industry.This chapter presents the results and conclusions of the research effort. . Appendix 4 would present the results of detailed statistical analysis of the responses to support the results presented in this chapter

CONTENT

The initial Literature review included a CII research RT 40 titled "Continuing Supervisory Education" conducted in 1995 that identified critical supervisory competencies in supervisors in an organization. Compiling the competencies defined in the research team 40 along with the recommended competencies in construction project managers as identified in RT 306, the research team members narrowed down from a list of hundred and fifty skills to ten desired competencies. It is also important to note that along with identifying the core competencies from available Literature, the list consisted of competencies as defined by competency assessment criteria used within the organizations of the members of the research team. As a result of several iterations within the research team members, the list of core competencies as identified by the research team are as follows:

1) General Construction Knowledge
2) Trade Specific Knowledge
3) Verbal Communication
4) Written Communication
5) Pre-Planning
6) Problem Solving
7) Ethical Value System
8) People Management
9) Leadership
10) Proactive and Goal Driven

Each of the above-stated core competencies consists of a list of sub-tasks and responsibilities that are different in scope for both Foremen and General Foremen. For example; in pre-planning, Foremen responsibilities include setting crews and goals to identify daily production tasks and requirements whereas, General Foremen tasks are set on a broader scale and involve multiple crews and a schedule for several weeks. Each of the above competency is important for both Foremen and General Foremen, however, the scope of application varies between each of them. Table 1 below presents a detailed list of tasks and responsibilities for each of the ten competencies for both Foremen and General Foremen. This table explains the scope of each of the stated competencies identifying the Foremen and General Foremen definition, side by side, to explain the perspective of the research team in creating a comprehensive list of the desired competencies. It is important to note here that for competencies including 7. Ethical, 9. Leadership, and 10. Proactive and Goal Driven, there are no sub-tasks or examples included in the list as the team believes that the above-said competencies are self- explanatory.

Table 1 Foremen and General Foremen Competencies- Detailed responsibilities and scope

Skills/ Competencies	Foreman Definition	General Foreman Definition
1. **General Construction Knowledge**		
Incident prevention (Safety Management)	Daily / Specific to work area hazard analysis / Crew monitoring / coaching	Broader view, holding Foreman accountable, writing JSA / PTA, Auditing Process
How well do you prepare daily area hazard analysis		
Maintaining good housekeeping on the job	Specific to work area	Broader work area for all crews
2. **Trade Specific Knowledge**		
Maintain quality of production	Similar to GF	-
Quality control procedures	Implements procedure	Understands QC overall plan and assigns individual pieces of plan to Foremen for implementation
Determine work access needs and availability	Identify need of access to work	Identify best form of access for work site
3. **Verbal Communication**		
Ability to explain tasks	Ability to get craft to understand	Ability to lay out broader plan
Ability to give concise, complete and accurate instructions	Ability to get craft to understand	Ability to lay out broader plan
Communicating with other Supervisors	Ability to get accurate information to GF and receive instruction of plan. Coordination with other craft Foreman	Ability to speak with Management clearly and provide clear communication to Foreman. Coordination with other craft Foreman
4. **Written Communication**		
Develop, Write, monitor and maintain pre-task plans	Use of Foreman's card to identify daily task analysis in more detail than what is shown on a JSA/PTA	Development of JSA / PTA spelling out all tasks, hazards, and hazard solutions.
5. **Pre Planning**		
Setting and Knowing current priorities	Set for crews on daily basis	Set for all crews

Table 1 contd.

Skills/ Competencies	Foreman Definition	General Foreman Definition
Pre Planning contd.		
Managing time (using scheduled hours efficiently)	Daily / task oriented	Ability to multitask / coordination with other disciplines / broader scope
Planning and scheduling production	Setting goals for crews for daily production of tasks	Understanding productivity rates and planning work to crew size and schedule for several weeks
Maintain an adequate workforce	Manages craft workers to get most out of them. Recommending increase or decrease in workforce.	Identify size of workforce based on experience and expected production. Will monitor overall productivity of crews to ensure meeting schedule and budget.
6. **Problem Solving**		
Ability to anticipate and avoid problems	Challenges and opportunities with task / craft	Problems with sequence / process / manpower, material & equip availability / inter-discipline activity conflicts
Ability to recognize job conditions / signals that should prompt action	Challenges and opportunities with task / craft	Problems with sequence / process / manpower, material & equip availability / inter-discipline activity conflicts
Knowing how and why to take actions	Relative to scope (problems and opportunities) - specific vs. broader for GF	Relative to scope (problems and opportunities) - specific vs. broader for GF
Ability to be introspective and examine oneself	Emotional Quotient	Expect GF to better at it
Evaluate new employees to identify strengths and weaknesses	Craft level	Foreman and Craft level
Willingness to learn, participate, and show improvement	Similar to GF	-
Willingness to take responsibility and be accountable when necessary	-	-
Willingness / ability to positively influence others by reasoning with them	-	-
Willingness / ability to take proactive measures to avert or mitigate problems	-	-
7. **Ethical Skills (Trustworthy, fair, empathetic, and even handed)**		
8. **People Management (Task assignments, delegating, conflict resolution, discipline)**		

Table 1 contd.

Skills/ Competencies	Foreman Definition	General Foreman Definition
People Management contd.		
Assigning people tasks that match their skills and aspirations	Specific to craft and crew	Foreman level
Ability to properly solicit and use others' opinions and ideas	Specific to craft and crew	Foreman level
Managing work behavior of crew members	Specific to craft and crew	Foreman level
Influence overtime and related crew fatigue	Identify when crew/craft are ineffective	Identify when crew/craft are ineffective - know when to elevate / take action
9. **Leadership**		
10. **Proactive and Goal Driven**		

After defining the list of core skills and competencies, the research team progressed with data collection. The above list of core competencies was then distributed across superintendents and related personnel in North America (U.S. and Canada) in an online survey generated on a platform known as Qualtrics. The data collection effort electronically started in the Summer of 2016 to maintain the confidentiality of the respondents. The categories of respondents as identified in the survey are as follows:

1) Site Manager
2) Construction Manager
3) General Superintendent
4) Craft Superintendent
5) Project Manager
6) Project Director
7) Others

The importance to the productivity of the above-stated competencies was established with a 6 point Likert scale. The ratings included the following (1 No Importance, 2 Limited, 3 Slight, 4 Moderate, 5 High, 6 Extremely High Importance). Superintendents and related personnel responded to ascertain importance to productivity for both F and GF. The reason for preferring a 6-point scale is that studies emphasize that data from Likert scales becomes significantly inaccurate when the scale points are below 5 or above 7 points. The reason for not choosing 5 or 7 point scale is that the respondents feel comfortable in selecting the middle value in such cases and hence make the results insignificant. The scale is as follows:

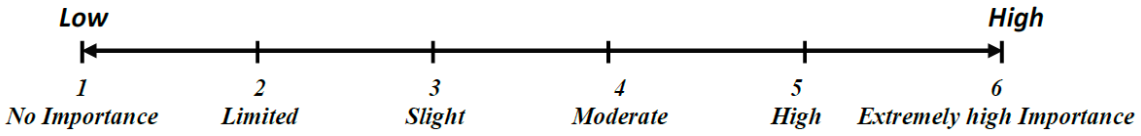


Figure 2 Likert scale- Importance of competencies

The research defines the importance to competencies on a 6-point scale. The ratings included the following (1 Inadequate/ Quite low, 2 Fair/ needs improvement, 3 Adequate/ neither low nor high, 4 Good- above average/ slightly high, 5 Very good/ quite high, 6 Excellent/ extremely high. To reinforce the findings from Superintendents and related personnel surveys on construction sites in North America (U.S. and Canada) were also asked to respond to the same question. An important distinction to be noted here is that GF surveys were distributed manually across construction sites maintaining the confidentiality

of respondents. It was deemed necessary to increase the response rate considering that all GFs do not necessarily have access computer at their workplace.

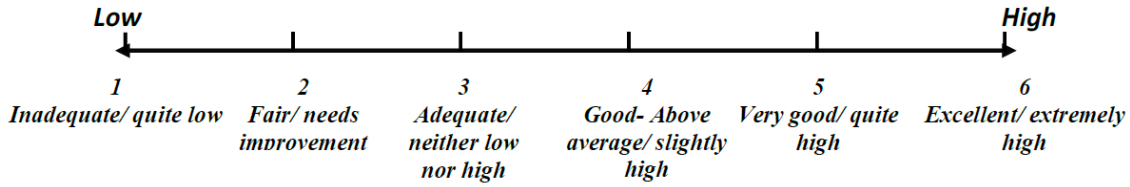


Figure 3 Likert scale- Current level of Competencies

After defining the Likert scales, the research team identified the survey population and ways to collect data. The surveys were distributed electronically to superintendents and managers with craft knowledge including site managers, construction managers, superintendents and project directors. The data collection effort commenced in the Summer of 2016. Before distributing the surveys, the electronic link to the survey was distributed within the internal network of participating team members to understand the areas of concern that might arise when the survey is distributed electronically to a larger audience. The surveys were created in an online platform Qualtrics. Qualtrics is a survey tool that is widely used in Social Sciences research and is an accepted medium to conduct statistical research in the University of Texas at Austin. Qualtrics survey tool provided detailed reports that along with providing the surveys as filled by each of the respondents, provided consolidated reports to analyze and compare data as considered necessary by the research team. Overall, an approach including statistical analysis of surveys reinforced with interviews across sites in North America collectively helped in establishing the research findings. It was found necessary to include both quantitative and qualitative analysis to

substantiate the findings. The sections below would explain the process utilized in competencies assessment.

After a successful pilot of the survey, the team distributed the surveys to the participating CII members. 61 Owner and 64 companies were screened to identify the participating companies to distribute the surveys electronically. The liaisons from target companies were contacted and recruited as a part of data collection efforts. RT330 is greatly obliged to the enthusiasm of CII member companies to help in data collection efforts.

Data analysis included analyzing mean scores and distribution of responses for each of the ten identified competencies for both importance and measurement for Foremen and General Foremen. The section below provides the list of competencies along with mean scores and percentages of distribution. By mean scores and distributions, the research team identified areas of improvement for both Foremen and General Foremen. This chapter provides industry-specific recommendations by statistical analysis of results.

RESULTS

A total of 72 respondents identified themselves as superintendents and managers with craft knowledge in the survey. The respondents included 7 site managers, 5 construction managers, 12 general superintendents, 26 craft superintendents, 12 project managers, one project director, and nine others. 5 out of 9 respondents in the Others category identified themselves as QA/QC welding manager, technical services manager, area manager, warehouse manager, and division manager.The chart below gives a breakup of the number of respondents. 53 % of respondents are general and craft superintendents.

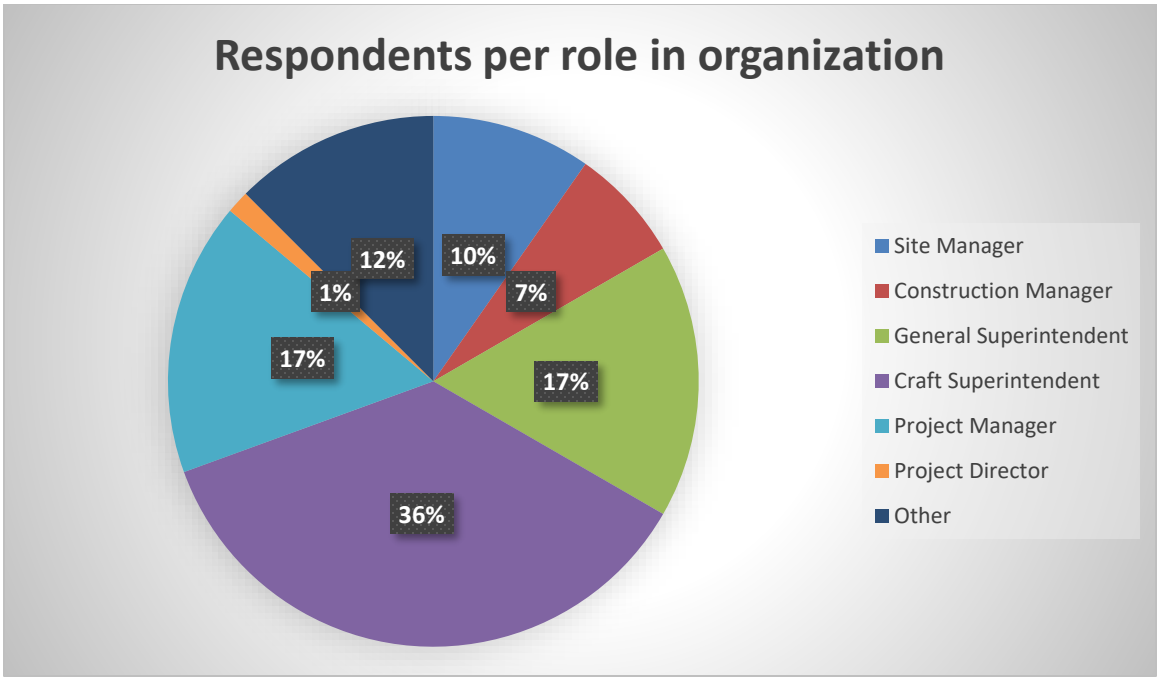


Figure 4 Superintendent survey- Respondents by role in the organization

The 10 competencies identified by the research team are found to be important to both F and GF. The data analysis effort included calculating averages of responses by Superintendents and Managers of craft knowledge. The ratings included in the 6-point survey scale are, 1 No Importance, 2 Limited, 3 Slight, 4 Moderate, 5 High, 6 Extremely High Importance. Importance rating averages are in Table 2 below. The lowest score for Foremen (F) is 4.45, and lies halfway between moderate and high importance, whereas the lowest score for General Foremen (GF) is 4.93, between moderate and high importance and tending towards high importance. In all cases, GF importance score is more than F. The top 5 competencies for F are ethical value system (5.46), trade specific knowledge (5.29), leadership (5.28), proactive and goal driven (5.24), and verbal communication (5.17). The top 5 competencies for GF are ethical value system and trade specific

knowledge (5.58), leadership and pre-planning (5.57), proactive and goal driven and people management (5.53), verbal communication (5.43) and problem-solving (5.37). Hence, top 5 competencies are same for both F and GF and all but 2 competencies rank in top 5 for GFs. With a mean score between 4 to 6 for each of the competencies defined by the research team for both Foremen and General Foremen, the research team concluded that all the proposed competencies are important in productive frontline supervisors.

Table 2. Competency Averages- Importance- Foremen and General Foremen (1-6 scale)

Competency	Foremen	General Foremen
General Construction Knowledge	4.73	5.32
Trade Specific Knowledge	5.29	5.58
Verbal Communication	5.17	5.43
Written Communication	4.45	4.93
Pre-Planning	5.12	5.57
Problem Solving	4.87	5.37
Ethical Value System	5.46	5.58
People Management	5.15	5.53
Leadership	5.28	5.57
Proactive and Goal Driven	5.24	5.53

As seen in Table 3 below, the percentage of respondents in the range of 1 to 3 (No importance to slight importance) is below 10 % for all competencies, but written communication for F. Maximum standard deviation is 0.98 for written communication. Another important observation is that only 1% of the respondents believe that out of the proposed list of competencies, are of limited importance (Likert point scale 2). 90 % of respondents believe that proposed competencies are within moderate and extremely high importance (Likert point scale 4-6) for all competencies but written communication. 85 % of respondents believe that written communication is within Likert point scale 4 and 6. Hence, overall the list of competencies as proposed are importance in increasing performance of F.

As seen in Table 4 below, the percentage of respondents in the range of 1 to 3 (No importance to slight importance) is below 5 % for all competencies but written communication for GF. The maximum standard deviation is 1.13 for written communication. Another important observation is that only 1% of the respondents believe that out of the proposed list of competencies, are of limited importance (Likert point scale 2)). 95 % of respondents believe that proposed competencies are within moderate and extremely high importance (Likert point scale 4-6) for all competencies but written communication. 90 % of respondents believe that written communication is within Likert point scale 4 and 6. Hence, overall the list of competencies as proposed are importance in increasing performance of GF. Another important observation for both Foremen and General Foremen is that the maximum number of respondents who rated them with regards to the importance of maintaining performance is 76 for Pre-Planning for both Foremen and

General Foremen. It is different from the counts of respondents who self-identified themselves at the beginning of the electronic survey. The percentages given below are by the counts presented in Tables 3 and 4.

Table 3. Competency assessment- Importance to performance- F

Competency	Likert Scale (Range 1-6)						Count
	1	2	3	4	5	6	
General Construction Knowledge	0.0%	0.0%	4.0%	34.7%	45.3%	16.0%	75
Trade Specific Knowledge	0.0%	0.0%	0.0%	13.7%	43.8%	42.5%	73
Verbal Communication	0.0%	0.0%	8.0%	12.0%	34.7%	45.3%	75
Written Communication	0.0%	2.7%	12.0%	38.7%	30.7%	16.0%	75
Pre-Planning	0.0%	0.0%	6.6%	14.5%	39.5%	39.5%	76
Problem Solving	0.0%	1.3%	4.0%	33.3%	29.3%	32.0%	75
Ethical Value System	0.0%	0.0%	2.8%	9.7%	26.4%	61.1%	72
People Management	0.0%	0.0%	4.1%	18.9%	35.1%	41.9%	74
Leadership	0.0%	0.0%	4.0%	12.0%	36.0%	48.0%	75
Proactive and Goal Driven	0.0%	0.0%	5.3%	10.7%	38.7%	45.3%	75

Table 4. Competency assessment- Importance to performance- GF

Competency	Likert Scale (Range 1-6)						Count
	1	2	3	4	5	6	
General Construction							
Knowledge	0.0%	0.0%	0.0%	14.7%	38.7%	46.7%	75
Trade Specific Knowledge	0.0%	0.0%	0.0%	8.2%	26.0%	65.8%	73
Verbal Communication	0.0%	0.0%	4.0%	9.3%	26.7%	60.0%	75
Written Communication	1.3%	0.0%	8.0%	22.7%	30.7%	37.3%	75
Pre-Planning	1.3%	0.0%	2.6%	6.6%	15.8%	73.7%	76
Problem Solving	0.0%	1.3%	1.3%	10.7%	32.0%	54.7%	75
Ethical Value System	0.0%	0.0%	1.4%	8.3%	20.8%	69.4%	72
People Management	0.0%	0.0%	2.7%	5.4%	28.4%	63.5%	74
Leadership	0.0%	0.0%	2.7%	6.7%	21.3%	69.3%	75
Proactive and Goal Driven	0.0%	0.0%	2.7%	6.7%	25.3%	65.3%	75

A significant finding of the research team is that competencies of F and GF are below desired levels. The data analysis effort included calculating averages of responses by Superintendents and Managers of craft knowledge. The ratings included in the 6-point survey scale are, 1 Inadequate, 2 Fair, 3 Adequate, 4 Good, 5 Very Good, 6 Excellent. Table 5 below provides competency rating.

The competencies range between adequate (3) and good (4) for foremen and good (4) to very good (5) for general foremen. These ratings are consistent with the general

industry approach of promoting talented crew to be F. It is also noted during several interviews of GF that the skill level of F is declining in the industry. Also, Industrial F are a transient workforce, and hence, less investment is seen in the industry to recruit, retain and train them effectively.

Table 5. Competency Averages- Competency level- F and GF (1-6 scale)

Competency	Foremen	General Foremen
General Construction Knowledge	3.64	4.28
Trade Specific Knowledge	4.05	4.53
Verbal Communication	3.75	4.21
Written Communication	3.29	3.92
Pre-Planning	3.56	4.20
Problem Solving	3.56	4.17
Ethical Value System	4.15	4.45
People Management	3.76	4.32
Leadership	3.85	4.38
Proactive and Goal Driven	3.81	4.24

The lowest score for F is 3.29, is between adequate and good and tends towards adequate competency level, whereas the lowest score for GF is 3.92, between adequate and good and tending towards good. In all cases, GF competency level is more than F. The bottom 5 competencies for F are written communication (3.29), pre-planning and problem

solving(3.56), general construction knowledge (3.64), verbal communication (3.75), and proactive and goal driven (3.81). The bottom 5 competencies for GF are written communication (3.92), problem-solving (4.17), pre-planning (4.20), verbal communication (4.21), and proactive and goal driven (4.24). The overall competency level for GF is more than that for F. However, the list of competencies is the same for both F and GF. Written communication is the lowest rated competency for both F and GF (3.29 and 3.92). Another important observation is that for both Foremen and General Foremen the 3 competencies with the lowest scores remain written communication, pre-planning, and problem-solving. Considering the responsibilities on both Foremen and General Foremen and the nature of work done on a day to day basis, these three areas which are concluded to be inadequate shows a need for improvement in the competencies for our frontline supervisors.

In Table 6 below for Foremen, the percentage of respondents in the range of 1 to 3 (Inadequate to adequate) is in the range of 40% to 55% for all competencies but trade specific knowledge (28.8%) and ethical value system (31.1%). Maximum standard deviation is 1.28 for proactive and goal driven. Further, as can be seen in the table, most of the 10 skills have a significant percentage of ratings in the inadequate and fair levels (levels 1 & 2). Similarly, only 2 competencies have 10% or more of the ratings in the excellent level (level 6). A large percentage of responses in the range of inadequate to the adequate range and a diminutive percentage in excellent level indicates room for improvement. Further for F, for written communication, nearly 30 % of the F fall in the inadequate (1) to fair zone (2). Similarly for pre-planning nearly 22 % of the F fall in the range. For problem-solving nearly 17 % of the F fall in the range.

As seen in Table 7 below, the percentage of respondents in the range of 1 to 3 (Inadequate to adequate) is in the range of 15% to 30%. The maximum standard deviation is 1.28 for written communication. Further, as can be seen in the table, most of the 10 skills have a significant percentage of ratings in the inadequate and fair levels (levels 1 & 2). Similarly, none of the responses have a percentage above 20% in the excellent level (level 6). A large percentage of responses in the inadequate to adequate ranges and only a diminutive percentage in the excellent level indicates room for importance. The current competency level of GF is higher than F, however remains alarming.

Table 6. Competency assessment- Current level- F

Competency	Likert Scale (Range 1-6)						Count
	1	2	3	4	5	6	
General Construction Knowledge	1.4%	5.6%	40.3%	34.7%	16.7%	1.4%	72
Trade Specific Knowledge	0.0%	6.9%	21.9%	37.0%	27.4%	6.9%	73
Verbal Communication	1.4%	14.1%	23.9%	36.6%	16.9%	7.0%	71
Written Communication	5.6%	23.6%	25.0%	31.9%	9.7%	4.2%	72
Pre-Planning	1.4%	21.4%	28.6%	25.7%	14.3%	8.6%	70
Problem Solving	2.8%	14.1%	29.6%	35.2%	14.1%	4.2%	71
Ethical Value System	0.0%	4.2%	26.8%	32.4%	22.5%	14.1%	71
People Management	2.8%	11.3%	26.8%	31.0%	22.5%	5.6%	71
Leadership	0.0%	12.5%	31.9%	23.6%	22.2%	9.7%	72
Proactive and Goal Driven	1.4%	15.3%	27.8%	23.6%	20.8%	11.1%	72

Table 7. Competency assessment- Current level- GF

Competency	Likert Scale (Range 1-6)						Count
	1	2	3	4	5	6	
General Construction Knowledge	0.0%	1.4%	19.7%	39.4%	28.2%	11.3%	71
Trade Specific Knowledge	1.4%	1.4%	12.3%	30.1%	37.0%	17.8%	73
Verbal Communication	0.0%	7.1%	20.0%	32.9%	24.3%	15.7%	70
Written Communication	2.8%	11.1%	23.6%	29.2%	20.8%	12.5%	72
Pre-Planning	0.0%	7.1%	24.3%	30.0%	18.6%	20.0%	70
Problem Solving	0.0%	8.3%	18.1%	33.3%	29.2%	11.1%	72
Ethical Value System	0.0%	1.4%	19.7%	28.2%	33.8%	16.9%	71
People Management	0.0%	4.2%	18.3%	36.6%	22.5%	18.3%	71
Leadership	0.0%	4.2%	25.0%	22.2%	26.4%	22.2%	72
Proactive and Goal Driven	0.0%	8.3%	20.8%	29.2%	22.2%	19.4%	72

The mean score of responses for foremen indicate that the current skills and competencies for frontline supervisors especially foremen are week and need improvement. It indicates a need for the industry to make a unified effort to increase the performance of frontline supervisors by recruiting, training, and retaining them effectively. Frontline supervisors have a significant role in supervising and motivating their crew and this research highlights the need and challenge for the industry to assist them to be better performers.

CONCLUSIONS

The results of surveys conducted have validated the hypothesis that in general, Foremen and General Foremen competency levels in the industry are below desirable levels. Survey data supports the hypothesis that both. It is exacerbated by the fast track progress in industrial construction projects, increased cognitive load, and employee management procedures. These, in turn, raise the visibility of Foremen and General Foremen inadequacies and with it rises a concern to improve the competency level in frontline supervisors to increase construction productivity on industrial construction projects.

Further, three competencies including written communication, pre-planning, and problem-solving are weak in both Foremen and General Foremen. As explained above, considering the importance of frontline supervisors in maintaining construction productivity and the huge number of frontline supervisors in large and complex industrial construction projects, there is a challenge in the industry to make a unified effort to address the challenges due to skill shortage in the leaders of the workforce.

The research identifies the 10 core competencies in productive frontline supervisors. The competencies identified by the research are general construction knowledge, trade specific knowledge, verbal communication, written communication, pre-planning, problem-solving, ethical value system, people management, leadership, and proactive and goal driven. It also establishes that the overall skills and competencies of frontline supervisors are weak. Three competencies including written communication, pre-planning, and problem-solving are weak and indicate room for improvement. The mean

score of responses combined with the percentage of respondents in the inadequate and fair range have helped the research team to validate the research hypothesis and essential questions. Tables 2 and 5 provide granular analysis of the competencies importance and performance.

Principal conclusions of this chapter are as follows:

1) Foremen and General Foremen have 10 core competencies that are consistently important to their performance. The competencies identified by the research are general construction knowledge, trade specific knowledge, verbal communication, written communication, pre-planning, problem-solving, ethical value system, people management, leadership, and proactive and goal driven. Out of the 10 core competencies, overall, ethical value system, trade specific knowledge, leadership, proactive and goal driven, and verbal communication are top 5 competencies in both Foremen and General Foremen. Overall the mean scores for each of the ten competencies indicate that all the identified competencies are very important to increase construction productivity and performance.
2) Survey data supports the hypothesis that both Foremen and General Foremen competency levels in the industry are below desirable levels. Three competencies including written communication, pre-planning, and problem-solving have very low mean scores for both Foremen and General Foremen. Also, the percentage of respondents in the inadequate to the fair range further reinforces the findings. It is is particularly true for Foremen. Investment and organizational buy-in to effectively

recruit, train, retain may be one of the biggest opportunities for improvement of the construction industry productivity and performance.

3) Also, training and organizational buy-in to support training of frontline supervisors is important to increase the performance of frontline supervisors.

Chapter 3: Industrial Construction Frontline Supervisors Time on Tasks

SUMMARY

Frontline supervisors directly motivate and supervise craftsmen and are responsible for maintaining productivity and performance on industrial construction projects. With a complex role including a myriad of responsibilities, there is an increased cognitive demand on the frontline supervisors. To maintain production and effectively undertake their responsibilities including supervising and motivating their crew, it is essential to gauge key areas where frontline supervisors spend their time on a daily basis. This chapter focuses on identifying the crucial tasks executed by productive frontline supervisors, their respective ideal time ranges and an assessment of time spent on industrial construction sites in North America (The US and Canada) by surveying frontline supervisors. It also illustrates separately time spent by specific crafts including the following crafts: Ironworkers, Mechanical/Millwrights, Pipefitters and Welders, Electrical/Instrumentation, Carpenters/Scaffolders, and Boilermakers. The reasoning behind performing analysis on these crafts is that in industrial construction, these crafts have maximum influence in supporting and maintaining production and hence are sometimes known as direct crafts. The principal findings include frontline supervisors spend their time in wide ranges across tasks that vary both from each other and the ideal ranges. Identification and assessment of time spent by frontline supervisors on crucial tasks are great opportunities for improving the performance of industrial frontline supervisors.

INTRODUCTION

The importance of construction foremen in motivating workers, assuring safety and quality, and efficiently conducting work has been recognized in several studies (Senior 1996). They are a crucial link between the management and workforce (Uwakweh 2005). They are expected to manage, plan and define work, communicate with workers, and motivate them to perform at acceptable levels (Uwakweh 2005). Their performance has a significant impact on the cost and schedule of industrial capital construction projects. The dynamic and complex nature of these projects intensifies the cognitive load and responsibilities on frontline supervisors. The need to increase predictability and performance of industrial construction projects is reinforced by the fact that in the industrial sector 70 % of the projects exceeded 10 % variation from the expected schedule and cost values (Choo et al. 1999). Both owner and contractor organizations need a unified effort to improve the performance of frontline supervisors in industrial construction.

However, the transient nature of industrial construction foremen makes it difficult for contractors to justify the cost of investment in developmental training or performance improvement. The research team believes that to improve the performance of industrial construction frontline supervisors, it is imperative to understand the key areas where they spend their time on a typical work day. An analysis of time spent and key tasks undertaken would be useful to understand the areas which pose opportunities for the industry to improve.

The purpose of this research is to identify the major tasks and responsibilities undertaken by construction foremen and general foremen during a typical work day. The

efforts involved identifying ten and eight major tasks and responsibilities for Foremen and general foremen respectively by utilizing a Delphi Approach. Along with identifying the tasks, the proposed time ranges are also provided in this chapter. The ten tasks for foremen include, attending meetings, planning and prioritizing fallback work, performing safety related activities, completing paperwork, coordinating with other crews, supervising, motivating, and executing, planning for future work, working on tools with the crew, receiving and verifying materials, and moving crews to contingency work. The eight tasks for general foremen include attending meetings, planning and prioritizing fallback work, performing safety related activities, constraint management, following up with foremen and crews, work package development, communicating with field engineers, and completing progress sheets.

This chapter firstly establishes what composes a "Productive Day" for Foremen and General Foremen. It secondly establishes that frontline supervisors in industrial construction projects are not spending their time in the proposed ideal time ranges as defined by the research team. The research efforts included surveying a population of frontline supervisors on different construction sites spread demographically across North America working in different production environments. By analyzing the responses, the research team concluded which tasks and responsibilities reflect the areas of improvement and pose a challenge for the industry.

Foremen tasks including task 5 "Coordinating with other crews," task 6, "Supervising/Motivating/Executing," task 9 "Receiving and checking Materials," and task 10 "Moving Crews to contingency work" are the areas which demand the industry attention

and pose areas for improvement. General Foremen tasks including task 2 "Planning/Prioritizing tasks," task 4 "Constraint Management," and task 6 "Work Package Development" are the areas where General Foremen are spending less time than the proposed time ranges, which is also reflected in the Foremen Time allocation. The research team believes that identification of potential areas is crucial to increase construction productivity and performance of frontline supervisors in industrial construction projects.

LITERATURE REVIEW

Frontline supervisors play a vital role in increasing construction productivity and performance. They influence their crews and play a significant role in their performance. Previous studies have elaborated on the influence of frontline supervisors on their crews and the different tasks undertaken by them during a typical workday. Argyle et al. investigated the effects of different styles of first-line supervision on productivity (Argyle et al. 1957). Hinze and Kuechenmeister investigated the characteristics and common traits of productive industrial foremen (Hinze and Kuechenmeister 1981). Lemna et al. identified characteristics of industrial foremen and their effect on construction productivity (Lemna et al. 1986). Maloney and McFillen identified five dimensions of foremen performance and their relationships with worker motivation, performance, and satisfaction (Maloney and McFillen 1987). Shohet and Laufer identified the correlation of foremen time spent during a workday with the performance of their crews (Shohet and Laufer 1991). Senior elaborated on foremen planning behind short-term task scheduling (Senior 1996). Uwakweh identified seven foremen scales to establish their relationship with the motivation and performance of construction apprentices (Uwakweh 2005).

These studies illustrate the influence of frontline supervisors on their craftsmen and increasing construction productivity and performance. They also illustrate that the time spent by frontline supervisors on different tasks during a workday influences the performance of their crew and construction productivity. However, they do not deeply delve and elaborate on the typical work day of frontline supervisors. However, this research identifies the tasks and responsibilities and also identifies the room for improvement by conducting a country-wide survey of Foremen and General Foremen. Also, the wealth of survey responses helps the research team to establish the research results and analyze the responses across projects in the North America. The research team believes that the research effort is important and imperative to firstly understand and then improve the performance of frontline supervisors in industrial construction projects.

RESEARCH QUESTIONS

As illustrated in the previous section, past studies provide diminutive analysis of typical workday of a frontline supervisor. Considering the importance of frontline supervisors in motivating and supervising their crew, the research team puts forward the importance to understand where do frontline supervisors spend their time on a typical work day. This chapter elaborates on the time spent on crucial tasks by industrial construction foremen and general foremen. Along with establishing the ideal ranges for each of the ten crucial tasks for foremen and eight crucial tasks for general foremen, this chapter publishes results of statistical analysis of surveys to support the research hypothesis that frontline supervisors spend time away from the ideal time ranges as defined by the research. The research questions addressed in this chapter are as follows:

1. What are the critical tasks and their corresponding ideal times executed by productive frontline supervisors during a typical workday?
2. Where do the industrial frontline supervisors spend their time during a typical workday and what is the difference between the proposed ideal and actual times?

RESEARCH METHODOLOGY

Use of statistical analysis to measure the performance of industrial construction foremen is seen historically. Lemna et al. (1986) statistically determined the characteristics which differentiated productive industrial construction foremen from less productive industrial construction foremen by Kendall correction analysis (Lemna et al. 1986). Shohet and Laufer established a correlation between the way a construction foreman divides his time and the performance of his crew by performing student t-tests on a sample of construction foremen in the US and Israel (Shohet and Laufer 1991). Warr and Bird assessed the training needs of foremen by establishing a correlation between foremen attitudes and their relationship with their subordinates and superiors in different construction environments (Warr and Bird 1967). Gilmour and Lansbury identified the training and development needs of first-line supervisors by studying the managerial behavior of 1200 first-line supervisors (Gilmour and Lansbury 1986).

Keeping in mind, the research hypothesis and questions, the research team firstly establsihed the tasks for both foremen and general foremen. The research team believed that to analyze the perfromance of frontline supervisors, it was important to benchmark the tasks and identify ideal ranges to compare the responses received. After several iterations within the research team, firstly a list of tasks and their corresponding times was piloted

within a small population of respondents. The responses received convinced the research team to simplify the approach and present proposed ranges of times within the survey, to help respondents with their thought process and correctly identify the time ranges for tasks on a typical work day. This established the list of tasks and their corresponding time ranges. Foremen and General Foremen surveys are presented in Appendix 2 and 3 of this thesis respectively. After identifying the crucial tasks and finalizing proposed ideal time ranges or the proposed "Productive Day", the surveys were distributed electronically and on paper to industrial construction sites in North America. Responses were received from different states and also represented different construction environments and trades. The overwhelming response rate helped the research team to present the results and support the research hypothesis. Next stage involved statistical analysis of the responses. A detailed analysis and the evidences to support resarch hypothesis have been presented in this chapter. Appendix 5 would present the results of detailed statistical analysis of the responses to support the results presented in this chapter. The next section would explain the tasks and also present in detail the survey instruments and mode of analysis.

CONTENT

The Stage 1 included identifying crucial tasks that a foreman and general foreman should undertake ideally on a productive day. The research efforts started with developing a survey instrument to identify the time spent by frontline supervisors on seventeen preselected tasks. The survey was piloted, and the responses received provided evidence that frontline supervisors did appropriately address the time spent, as the total of the number of minutes spent on those tasks during a day did not account for the number of

minutes in one shift of 10 hours i.e. 600 minutes. Preliminary survey responses supported the need to provide the respondents with fixed time ranges that would facilitate them to answer the questions by choosing amongst three available options rather than summing up the time allotted to activities during a typical workday.

The second iteration involved finalizing ten crucial foremen tasks and eight crucial general foremen tasks on a typical work day of an industrial construction site. The Delphi method was used to identify and finalize the above tasks. Hallowell and Gambatese defined the Delphi method to be a systematic and interactive research technique for obtaining the judgment of a panel of independent experts on a specific topic (Hallowell and Gambatese 2010). After multiple rounds of discussion between the expert panelists who have served the construction industry in different production environments and a facilitator, the group came up with the proposed tasks and their corresponding ideal percentages of time. These percentages were finalized considering the ideal percentages to allow frontline supervisors to focus their efforts to increase their crew productivity.

Table 8 below illustrates the ideal percentages for a "Productive day" for a foreman. The ten crucial foremen tasks include meetings, planning for future work, safety-related activities, completion of paperwork, coordination with other crews, supervising and motivating their crew, receiving and verifying materials, and moving crews to contingency work. Out of the ten tasks, on a productive day, the foremen should ideally spend maximum time in supervising and motivating their crew. Considering that out of a typical shift time of 10 hours; an industrial construction foreman should be ideally spending no less than 6 hours in motivating his crew. This portion of work should be where a construction Foreman

in industrial construction projects should be spending maximum time. Of the remaining forty percent of the time, he should spend nearly ten percent in planning for future work. It can be seen in Table 9 below that necessarily not all tasks might be considered as productive tasks but are seen as a necessary evil by the members of the research team. For example, during a typical workday Foremen should ideally spend no more than 7 % in doing paperwork. For example in a 10 hour day, a foreman should not be spending more than approximately half an hour in doing paperwork. Similarly, holds for checking and verifying materials on the site, a foreman should ideally not be spending more than 10 minutes in receiving material.

Table 8 Foremen tasks during a "Productive Day"

Foremen Task	**"Productive Day"**
1. Meetings – Client/Coordination/Scheduling/Look Ahead	8 %
2. Plan/Prioritize Tasks & Fallback Work (Plan "B")	4 %
3. Safety Related Activities – Meetings/JHA Development/Inspections/Action Items/Sign/Review FLHAs	2 %
4. Complete Paperwork	7 %
5. Coordinate with other Crews/Support	2 %
6. Supervise/Motivate/Execute	60 %
7. Plan for Future Work	10 %
8. Work on Tools with Crew	3 %
9. Receive/Check/Verify Materials in Area	2 %
10. Move Crews to Contingency Work	2 %

Figure 5 below depicts the same data in the form of a pie chart. Previous literature divides time into productive and non-productive days. However, a detailed and granular analysis which asks the frontline supervisors to self-report where they are spending their time on a typical work day has not been done in the past. The intent of the research team was to provide a detailed analysis which would help in identification of specific areas of concern and assist in specific action items and recommendations to the industry.

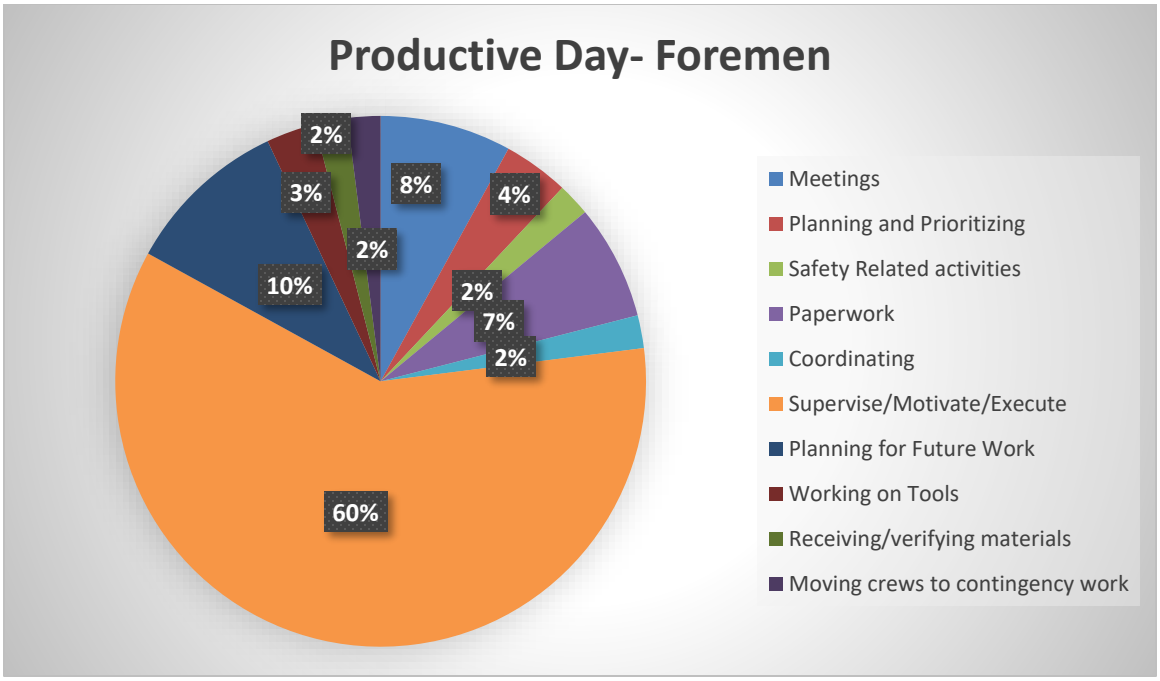


Figure 5 Productive Day- Foremen

Table 9 below illustrates the ideal percentages for a "Productive day" for a General Foreman. The eight crucial tasks for a general foreman include attending meetings, planning and prioritizing, safety-related activities, constraint management, following up with foremen their crews, developing work packages, communicating with field engineers, and progress reporting. A general foreman should ideally spend 70 % of his time in making sure that his foremen are productive by ensuring that his responsibilities include planning and prioritizing for his foremen, constraint management, following up with foremen, work package development, and communicating with field engineers.

Table 9 General Foremen tasks during a "Productive Day"

General Foremen Task	**"Productive Day"**
1. Meetings – Client/Coordination/Scheduling/Look Ahead	20 %
2. Plan/Prioritize Tasks & Fallback Work (Plan "B") with Foremen	10 %
3. Safety Related Activities – Meetings/JHA Development/Inspections/Action Items/Sign/Review FLHAs	7 %
4. Constraint Mgt. – Ensure FM has all Crane support/crane/scaffold/Material/Equipment	12 %
5. Follow up with FM & Crews Throughout Day – Work Area Reviews/Productivity Check in Field	25 %
6. Work Package Development – Model Review/FIWP Review/FIWP Schedule/Close-Out FIWPs	15 %
7. Communicate with Field Engineers – Develop Estimates for Extra Work/RFIs	5 %
8. Complete Progress/Timesheets/Forecasts/Review Installed Quantities/Cost Codes	6 %

Figure 6 below depicts the same data in the form of a pie chart. Previous literature divides time into productive and non-productive days. However, a detailed and granular analysis which asks the frontline supervisors to self-report where they are spending their

time on a typical work day has not been done in the past. The intent of the research team was to provide a detailed analysis which would help in identification of specific areas of concern and assist in specific action items and recommendations to the industry. The team proposes that a General Foreman should spend maximum time in planning and prioritize work for his Foremen. It is to make sure that all contingency planning including planning and prioritizing tasks and fallback work should be by the critical/longest past on the construction schedule and not just a mere firefighting and take up hot ticket items for the time being. Other tasks including constraint management, work package development are also taken up by the General Foremen.

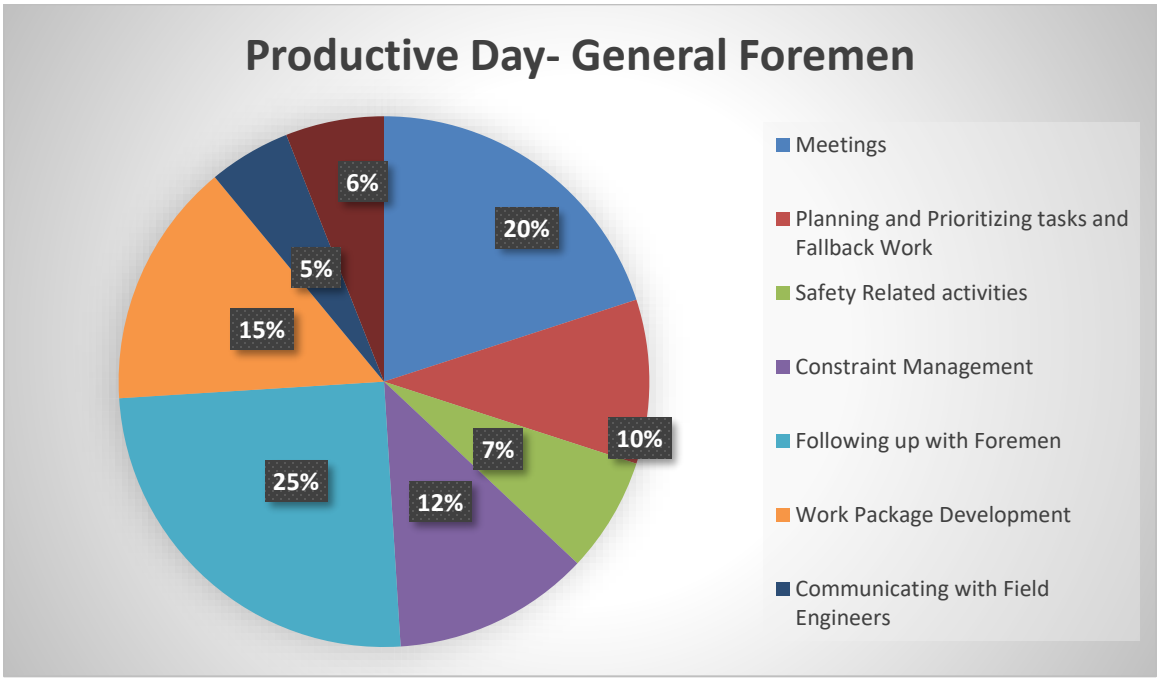


Figure 6 Productive Day- General Foremen

The next steps involved assigning three-time ranges to each of the tasks above, with one of the time range being the ideal range as decided by the members of the research team.

For each of the crucial tasks, the three time ranges for all of the ten and eight tasks respectively for foremen and general foremen are defined in Tables 10 and 11 below. The time ranges highlighted in yellow correspond to the percentages as defined in Tables 8 and 9 and hence are the proposed ideal time ranges as defined by the research team. For instance, a foreman should ideally spend 60 percent of his time in supervising and motivating his crew. Considering, a typical day of usually 8 or 10 hours, 60 % would correspond to a time range of 5-6 hours, as defined as the ideal range for this sub-task in Table 10. The team performed an analysis on all ten foremen tasks considering a typical shift time of 10 hours to reinforce the ideal time ranges. To pick up a category randomly for a General Foreman, as per percentages are given in Table 9, a General Foreman should ideally spend 25 % of his time on following up with his foremen and their crews. In a typical day of 8 or 10 hours, 25 % would correspond to a time range of 2-2.5 hours, as defined as the ideal range for this sub-task in Table 11. The team performed an analysis on all eight general foremen tasks considering a typical shift time of 10 hours to reinforce the ideal time ranges. The tables below are valid for all 8,10, and 12 hour days on an industrial construction site for both Foremen and General Foremen.

Table 10 Foremen tasks during a "Productive Day"- Ideal ranges

Task	Minutes/Hours Per Day Spent		
1. Meetings – Client/Coordination/Scheduling/Look Ahead	15-60 mins.	1.5-2 hrs.	2-4 hrs.
2. Plan/Prioritize Tasks & Fallback Work (Plan "B")	0-30 mins.	45-90 mins.	2-3 hrs.
3. Safety Related Activities – Meetings/JHA Development/Inspections/Action Items/Sign/Review FLHAs	0-15 mins.	30-60 mins.	1.5-3 hrs.
4. Complete Paperwork	10-25 mins.	30-60 mins.	65-90 mins.
5. Coordinate with other Crews/Support	0 mins.	5-15 mins.	16-25 mins.
6. Supervise/Motivate/Execute	4 hrs. or less	5-6 hrs.	8 hrs. or more
7. Plan for Future Work	15-35 mins.	45-1.25 hrs.	1.5-2 hrs.
8. Work on Tools with Crew	0-15 mins.	15-45 mins.	1-2 hrs.
9. Receive/Check/Verify Materials in Area	0 mins.	5-15 mins.	16-25 mins.
10. Move Crews to Contingency Work	0 mins.	5-15 mins.	16-25 mins.

Table 11 General Foremen tasks during a "Productive Day"- Ideal ranges

Task	Minutes/Hours Per Day Spent		
1. Meetings – Client/Coordination/Scheduling/Look Ahead	15-60 mins.	1.5-2 hrs.	2-4 hrs.
2. Plan/Prioritize Tasks & Fallback Work (Plan "B") with Foremen	0-30 mins.	45-90 mins.	2-3 hrs.
3. Safety Related Activities – Meetings/JHA Development/Inspections/Action Items/Sign/Review FLHAs	0-15 mins.	30 -60 mins.	1.5-3 hrs.
4. Constraint Mgt. – Ensure FM has all Crane support/crane/scaffold/Material/Equipment	0-30 mins.	60-90 mins.	2-3 hrs.
5. Follow up with FM & Crews Throughout Day – Work Area Reviews/Productivity Check in Field	30-45 mins.	1.5-3 hrs.	4-6 hrs.
6. Work Package Development – Model Review/FIWP Review/FIWP Schedule/Close-Out FIWPs	0-30 mins.	1-2 hrs.	3-4 hrs.
7. Communicate with Field Engineers – Develop Estimates for Extra Work/RFIs	0-15 mins.	30-60 mins.	1.5-3 hrs.
8. Complete Progress/Timesheets/Forecasts/Review Installed Quantities/Cost Codes	0-15 mins.	30-60 mins.	1.5-3 hrs.

The ideal time ranges as defined in the above two tables necessarily form a pattern with all ideal time ranges typically in the middle row which can result in a bias in which respondents respond to the surveys. However, initial pilot surveys and final surveys from respondents in industrial construction in the North America reveal that the respondents

responded over a wide range of responses different from each other and the ideal time ranges. The surveys were carefully constructed and piloted to provide useful answers that could also easily be responded. The ideal time ranges are proposed to apply equally to all production environments including Advanced Work Packaging (AWP), traditional, and maintenance environments. AWP is a disciplined approach to improving project productivity and predictability by aligning planning and execution activities throughout the project lifecycle, from project set-up to start-up and turnover (Construction Industry Institute 2013a)

Stage 2 commenced with the beginning of data collection efforts. Representatives were contacted on industrial sites in North America to recruit them to distribute surveys on their respective industrial sites. In this process, the representatives distributed chapter-based surveys to the respondents, maintaining the confidentiality of respondents.

A total of 1135 responses (812 Foremen, 323 General Foremen) responded from the sites across North America. Of them, 240 responses from Advanced Work Packaging/ Workface Planning (AWP/WFP), with 188 Foremen and 52 General Foremen. 631 responses from traditional sites with 438 Foremen and 193 General Foremen. 264 responses from Maintenance sites, with 186 Foremen and 78 General Foremen. Out of these responses including crafts Ironworkers, Mechanical/Millwrights, Pipefitters, Electrical/Instruments, Carpenters/Scaffolders, and Boilermakers, a total of 787 responses out of which 577 were Foremen, and 210 were General Foremen. The research received a wide range of projects including petrochemical projects, power plant projects, and chemical plant projects. Respondents from a total of 24 projects in Canada, Central US,

Southwest US, and Southeast US participated. A wide range of projects, demographic locations, production environments, and project type have enabled the researchers to reinforce their findings.

Figures 7 and 8 below would provide a breakdown per craft for both General Foremen and Foremen respectively. Maximum percentage of respondents for General Foremen include Pipefitters (24 %) and Electrical/Instruments (15 %). For Foremen, the maximum percentage of respondents include Pipefitters (24 %), Ironworkers (15%), and Electrical/Instruments and Civil/Labor (14 %). Overall the distribution of crafts for Foremen and General Foremen follow the same distribution with Pipe/fitters and Electrical/Instrumentation being the predominant crafts in both the populations.

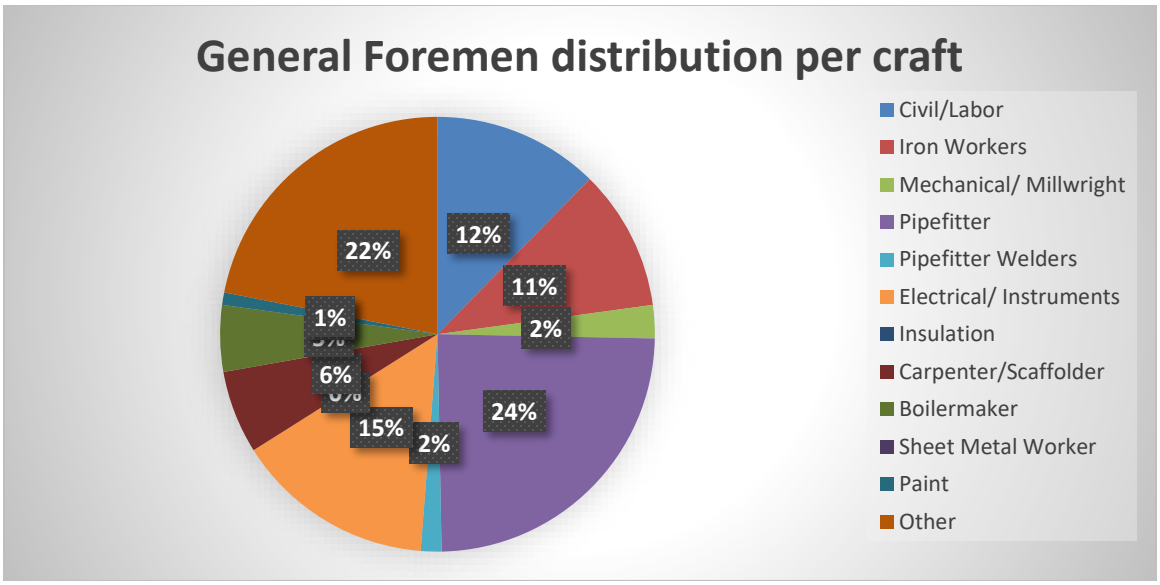


Figure 7 General Foremen distribution per craft- all projects

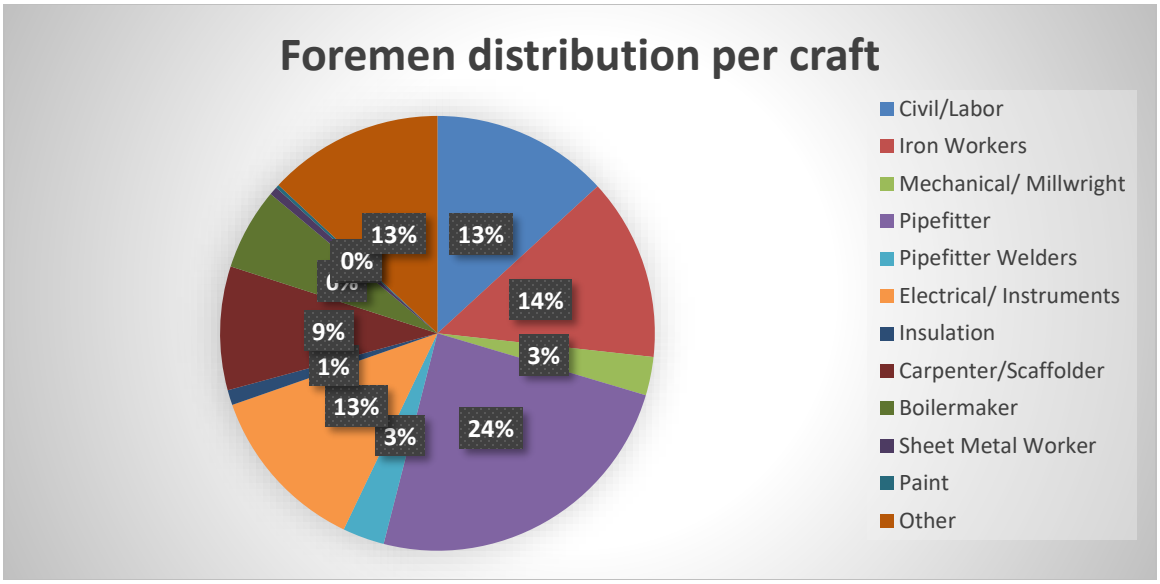


Figure 8 Foremen distribution per craft- all projects

Stage 3 involved analysis of responses for each of the ten and eight categories for both Foremen and General Foremen. The analysis was done in two steps, first for all projects and all crafts. The second part of the analysis was performed only for crafts mentioned in the section above including Iron Workers, Mechanical/Millwrights, Pipefitters and Welders, Electrical and Instrumentation, Carpenters, and Boilermakers. A separate analysis for these crafts was performed to understand better how these crafts spend their time. The reasoning behind performing a separate analysis for these crafts is that they are directly involved and share more responsibility to increase performance and productivity in industrial construction projects.

The next stage involved providing industry specific recommendations based on the findings of the analysis of surveys. The suggestions and recommendations are for both owners and contractors specific to industrial construction projects. The RT 330 research team identifies that the time spent and productive day suggestions typically apply to

industrial construction projects, however, may have applicability to commercial and heavy civil construction projects.

RESULTS

The researchers analyzed the responses from 1135 frontline supervisors on industrial projects to account for how they spend their day. The survey results indicate that there is a great variation in how frontline supervisors spend their time on the 10 and 8 Foremen and General Foremen tasks respectively as described in the above sections.

Foremen and General Foremen indicate that they spend their day in a wide spread of times that vary considerably from the ideal. Table 12 shows percentages in each of the ranges for Foremen surveyed, representing approximately 800 respondents. Further, the reasoning behind the observation that all not rows for the ten categories total up to 812 that is the total number of respondents is because all of the respondents did not respond to each of the category listed in the survey. It illustrates that a significant percentage of Foremen could be allocating time more productively. While the researchers expected some spread in a survey, widespread of percentages indicates significant opportunities for improvement. As highlighted in Table 12, Considering Task 6, “Supervise/Motivate/Execute”, findings indicate that 24 % of the respondents spend 4 hours or less on this task when the ideal is 5-6 hours (8 hours or more is not seen as ideal- while not necessarily not a wrong thing to spend more time in the field with the crew, too much time on one task takes time from other valuable efforts). It is evident from this finding that nearly a quarter of foremen are spending less than 4 hours in supervising and motivating their crew. With evidence that a construction foremans main responsibility includes maintaining production and

supervising their crew, this finding indicates a challenge and room for improvement. For other tasks including Task 5, “Coordinate with other Crews/ Support,” Task 9 “Receive/Check/Verify Materials in Area,” and Task 10 “Move Crews to Contingency Work” majority foremen spend 16-25 minutes were they should not be spending more than 5-10 minutes in each task. For task 5 “Coordinate with other crews/support” nearly half of the respondents are spending more time than the ideal time range as proposed by the research team. Corresponding percentages of time spent by General Foremen in tasks including constraint management and work package development which is in detail in Table 13, definitely indicate a misbalance in the distribution of responsibilities between Foremen and General Foremen. Similarly, 55 % of Foremen spend more time than the proposed ideal time range by the team in receiving, checking, and verifying the material. Increased problems in the quality and availability of construction material, as would be discussed in the section of production impediments can be a testimony to this.

Table 12 Percent of Foremen responding in each range (ideal range is shaded)

Foremen Tasks				Count
1. Meetings Client/Coordination/Scheduling/Look Ahead	68.1%	26.5%	5.4%	803
2. Plan/Prioritize Tasks & Fallback Work (Plan B)	50.4%	43.7%	5.9%	794
3. Safety Related Activities/ Meetings/Job Hazards Analysis (JHAs) Development/Inspections/Action Items/Sign/Review	19.5%	72.4%	8.2%	810
4. Complete Paperwork	29.4%	52.6%	18.0%	812
5. Coordinate with other crews/support	2.4%	47.1%	50.5%	802
6. Supervise/ Motivate/ Execute	24.1%	36.5%	39.4%	803
7. Plan for Future Work	33.7%	49.9%	16.4%	793
8. Work on Tools with Crew	40.8%	33.8%	25.4%	802
9. Receive/ Check/ Verify Materials in Area	5.4%	39.7%	55.0%	802
10. Move Crews to Contingency Work	6.8%	50.3%	43.0%	796

Table 13 shows percentages in each of the ranges for General Foremen surveyed across all projects, representing nearly 300 respondents. Similarly, for General Foremen, all the rows corresponding to each of the eight General Foremen tasks does not total up to the total number of respondents as 323. It illustrates that a significant percentage of General Foremen could be allocating time more productively. While the researchers expected some

spread in a survey, widespread of percentages indicates significant opportunities for improvement.

Table 13 Percent of General Foremen responding in each range (ideal range is shaded)

General Foremen Tasks				Count
1. Meetings Client/Coordination/Scheduling/Look Ahead	49.5%	36.1%	14.3%	321
2. Plan/Prioritize Tasks & Fallback Work (Plan B)	28.9%	53.7%	17.4%	322
3. Safety Related Activities Meetings/Job Hazards Analysis (JHAs) Development/Inspections/Action Items/Sign/Review Field Level Hazard Assessments (FLHAs)	12.7%	74.9%	12.4%	323
4. Constraint Management Ensure Foreman has all Crane support/scaffold/material/equipment	47.9%	38.7%	13.4%	313
5. Follow up with Foreman & Crews Throughout Day Work Area Reviews/Productivity Check in Field	18.3%	47.8%	33.9%	322
6. Work Package Development Model Review/Field Installation Work Package (FIWP) Review/FIWP Schedule/Close-Out FIWPs	49.7%	45.8%	4.6%	308
7. Communicate with Field Engineers Develop Estimates for Extra Work/Request For Information's (RFIs)	33.7%	53.2%	13.1%	312
8. Complete Progress/Timesheets/Forecasts/Review Installed Quantities/Cost Codes	12.9%	70.0%	17.0%	317

On Task 4 for General Foremen- "Constraint Management- Ensure Foreman has all crane support/scaffold/material/equipment, 48 % of the respondents indicate that they spend time between 0 and 30 minutes a day performing. The ideal range for this task is 60-

90 minutes, In this case, the data indicates that there is a great opportunity for the General Foremen to spend more time in ensuring that constraints are resolved for Foremen and their crews to be more productive.

The research team infers that the General Foremen are not performing this task which in turn puts more burden on Foremen, which may be why for example, 55 % of foremen spend time in the highest time range for Task 5 and Task 9 as captured in the paragraph above. Similarly for Task 2 "Plan/ Prioritize Tasks and Fallback Work (Plan B)" 60 % of the respondents answer in the highest two-time ranges. Similarly for Task 6 "Work package development," 50 % of the General Foremen spend less time than the proposed ideal range by the research team. Foremen struggle in maintaining production due to inefficient engineering drawing management and information missing on the drawings. When General Foremen spend less time than the proposed time ranges by the research team in work package development, a considerable number of Foremen (24 %) spend less time than the proposed ideal ranges in supervising and motivating the crew. The main purpose of the research is to identify the key areas of improvement for both Foremen and General Foremen along with the external impediments to production.

The next stage in the analysis included aggregating responses from crafts including Ironworkers, Mechanical/Millwrights, Pipefitters/Welders, Electrical Instruments, Carpenter/Scaffolders, and Boilermakers. Table 14 below shows the percentage of Foremen responses for each of the ten foremen tasks for hard crafts. The total number of respondents as described above is 577 Foremen.

For direct crafts, the percentage of respondents in each of the three-time ranges as defined by the team for all 10 tasks for Foremen, show a similar spread as was observed when the analysis was performed for all the crafts for all projects. The corresponding percentages and the areas of concern are highlighted in the form of blue circles in Table 14. It is important to note here that the areas which showed the maximum scope of improvement and posed a challenge for the industry for all the crafts combined remain same for crafts only about the 7 crafts discussed above.

Table 14 Percentage of Foremen responding in each range- Hard crafts (Ideal range is highlighted)

Foremen Tasks				Count
1. Meetings Client/Coordination/Scheduling/Look Ahead	66.4%	27.6%	6.0%	566
2. Plan/Prioritize Tasks & Fallback Work (Plan B)	47.4%	47.2%	5.4%	559
3. Safety Related Activities/ Meetings/Job Hazards Analysis (JHAs) Development/Inspections/Action Items/Sign/Review	18.8%	73.3%	7.9%	570
4. Complete Paperwork	27.2%	52.3%	20.6%	574
5. Coordinate with other crews/support	2.5%	47.5%	50.0%	566
6. Supervise/ Motivate/ Execute	25.4%	38.5%	36.0%	566
7. Plan for Future Work	31.2%	50.8%	18.1%	565
8. Work on Tools with Crew	40.7%	35.1%	24.2%	570
9. Receive/ Check/ Verify Materials in Area	3.3%	37.5%	59.2%	568
10. Move Crews to Contingency Work	6.7%	50.2%	43.1%	566

Table 15 shows percentages in each of the ranges for General Foremen surveyed across all projects, representing 210 respondents. It illustrates that a significant percentage

of General Foremen could be allocating time more productively. This finding is of particular importance in General Foremen of the crafts mentioned above as these are the maximum beneficiaries of productivity enhancing practices as would be discussed in detail in the next chapter. While the researchers expected some spread in a survey, widespread of percentages indicates significant opportunities for improvement. The spread of responses across the three categories is slightly different for General Foremen in the 7 crafts discussed above. The areas of concern and tasks and responsibilities which indicate a challenge for the industry and room for improvement remain same, however. The three tasks including Planning and Prioritizing work for foremen, constraint management, and work package development are shown in Table 15 below.

Table 15 Percentage of General Foremen responding in each range- Hard crafts (Ideal range is highlighted)

General Foremen Tasks				Count
1. Meetings Client/Coordination/Scheduling/Look Ahead	49.5%	38.6%	11.9%	210
2. Plan/Prioritize Tasks & Fallback Work (Plan B)	28.1%	54.8%	17.1%	210
3. Safety Related Activities Meetings/Job Hazards Analysis (JHAs) Development/Inspections/Action Items/Sign/Review Field Level Hazard Assessments (FLHAs)	11.0%	77.6%	11.4%	210
4. Constraint Management Ensure Foreman has all Crane support/scaffold/material/equipment	45.4%	42.9%	11.7%	205
5. Follow up with Foreman & Crews Throughout Day Work Area Reviews/Productivity Check in Field	16.7%	52.2%	31.1%	209
6. Work Package Development Model Review/Field Installation Work Package (FIWP) Review/FIWP Schedule/Close-Out FIWPs	37.7%	56.4%	5.9%	204
7. Communicate with Field Engineers Develop Estimates for Extra Work/Request For Information's (RFIs)	25.6%	58.0%	16.4%	207
8. Complete Progress/Timesheets/Forecasts/Review Installed Quantities/Cost Codes	11.1%	71.6%	17.3%	208

The aggregate findings of the survey indicate that F and GF are spending considerable time on tasks apart from what the researchers consider to be the ideal or target ranges. The researchers believe that even small moves toward target ranges in aggregate can make an enormous difference. The researchers also acknowledge the fact that there are many reasons to why frontline supervisors spend their times differently than the ideal/

targeted ranges, including dynamic and complex project conditions, resource, and manpower ability. A widespread in the ranges within the respondents and variance from the ideal ranges indicate huge room for improvement.

CONCLUSIONS

The ten identified tasks for a Foremen as defined by the Research Team include attending meetings, planning and prioritizing tasks and fallback work, performing safety-related activities, completing paperwork, coordinating with other crews and support, supervising and motivating, planning for future work, receiving/checking/and verifying materials, and moving crews to contingency work. The eight identified tasks for General Foremen include attending meetings, planning and prioritizing fallback work with foremen, performing safety-related activities, constraint management, following up with foremen, work package development, communicating with field engineers, and completing progress/timesheets. This chapter provides detailed overview of the proposed ideal ranges by the research team.

After identifying the tasks during a "Productive Day," the Research team surveyed frontline supervisors in North America to understand where they are spending their time on a typical work day. The several hundred surveys conducted by RT330 have validated the research hypothesis that frontline supervisors spend time away from the proposed ideal time ranges as identified and defined by the Research Team. Their tasks and responsibilities exacerbates their condition. The steady decline of craft labor skills and increased safety and employee management processes and procedures have further posed a challenge to the industry. The Research team by defining the productive day for frontline

supervisors and by surveying the industry have identified the key areas and opportunities for improvement.

Foremen tasks including coordinating with other crews, supervising, motivating, and executing, receiving/checking/verifying materials, and moving crews to contingency work indicate that they are spending time away from their main responsibility which should be to maintain production and supervise their crew. Similarly, General Foremen tasks including constraint management and work package development indicate a misbalance between the split of responsibilities of foremen and general foremen on industrial construction sites.

Overall, the survey results have posed a great challenge to the industry to help frontline supervisors to divide their time effectively which would, in turn, affect the performance and productivity of industrial construction projects. The Research team also acknowledges the fact that external impediments to construction including late or inaccurate engineering deliverables, issues with the quality of construction material, unrealistic schedule expectations, lack of detailed pre-planning, and an inadequate support structure also negatively affect the performance of frontline supervisors. The principal conclusion of this chapter is that on all project types, Foremen and General Foremen spend a considerable amount of time away from what the research team designated as ideal or target time budgeted for their primary tasks. While some variation expected, better allocation of frontline supervisor time could yield significant productivity improvements.

It is recommended that the industry makes a step towards a unified investment in training frontline supervisors. Along with the investment, the industry needs to work to

reduce the external impediments to production which limits the capability of frontline supervisors to perform effectively. Efficient Pre-planning will sheild the production from unexpected production impediments, especially in complex industrial projects.

For problems including declining quality of construction materials, problematic engineering deliverables, and changes and rework in the field to name a few, should be tackled before they multiply on the field. Frontline supervisors, specially Foremen should be equipped to help them concentrate the most on their foremost responsibility to supervise and motivate their crew and spend maximum time on the field with their crew to increase construction productivity and performance.

Hence, the research team recommends the industry to analyze where their frontline supervisors are spending their time. Based on the conclusions of the statistical analysis of the surveys, the key areas of improvement are identified. It would enable the organizations to apply specific recommendations which would enable their frontline supervisors to increase their performance on industrial construction projects. The research team advises the industry to make unified efforts to address the challenges faced by frontline supervisors on their industrial construction projects.

Chapter 4: Influence of Advanced Work Packaging on Task Scheduling by Frontline Supervisors

SUMMARY

Frontline supervisors (Foremen and General Foremen) directly motivate and supervise craftsmen and are responsible for maintaining productivity and performance on industrial construction projects. With a complex role including a myriad of responsibilities, frontline supervisors divide their time into many crucial tasks during a typical workday. Considering the external production impediments in complex industrial construction environments, frontline supervisors struggle to spend their time productively. This chapter establishes the influence of a productivity buffering technique, Advanced Work Packaging (AWP) on the way frontline supervisors divide their time into crucial tasks during a work day. CII RT 272 defines AWP as a disciplined approach to improving project productivity and predictability by aligning planning and execution activities across the project life cycle, from project setup to startup and turnover (Construction Industry Institute 2013a). This chapter compares the time spent by Foremen and General Foremen on 10 and 8 predefined crucial tasks respectively during a typical day for those in traditional and AWP environments on industrial construction sites in North America (The United States and Canada) (statistical analysis of surveys with support from interviews). The principal findings include that the frontline supervisors in AWP environments are found to be spending their time more productively in comparison to their counterparts in traditional environments on construction projects with similar scope.

INTRODUCTION

Frontline supervisors- foremen and general foremen- are the managers who translate construction execution plans into productive action. Despite their importance, they have been comparatively understudied. Recent productivity research has focused on productivity buffering techniques such as Advanced Work Packaging (AWP) or worker shortage and lessening of craft skills. However, to implement productivity improvement initiatives or to address worker skills, it is imperative to focus on the capabilities of foremen and general foremen.

This chapter aims to understand where frontline supervisors spend their time during a typical work day in different production environments. The study compares responses by respondents spread demographically in North America from two different production environments: Traditional and Advanced Work Packaging (AWP). For survey questions, please refer Foremen and General Foremen surveys at the end of this thesis as Appendix 2 and 3. The reasoning behind this approach is to understand the key areas in which frontline supervisors in AWP work environment are seen to perform effectively in comparison to their counterparts in a traditional environment. The comparison between projects of similar scope including budget and production capabilities helps the researchers to reinforce their claim. The researchers support the survey results by interviews across different production environments. More focused responses from respondents in AWP projects in comparison to their traditional counterparts on the same questions within the interview questionnaire support the research hypothesis that AWP environment enables the frontline supervisors to allocate their time effectively.

A comparison of time spent on tasks for frontline supervisors with and without AWP training yielded statistically significant results in both traditional and AWP work environments. For foremen on traditional projects task 2, “Plan/Prioritize Tasks and Fallback Work (Plan B), task 5, “Coordinate with other crews/support”, task 9, “Receive/check/verify materials”, and task 8 “Work on Tools with Crew”, statistically significant results are seen in differences between those with and without training. For General Foremen tasks including task 2, “Plan/prioritize tasks and fallback work with Foremen,” and task 6, “Workpackage Development,” statistically significant differences are observed between those with and without AWP training. Similarly, a comparison of time spent for those with and without AWP training on AWP projects also yielded statistically significant differences between those with and without AWP training. For Foremen tasks including task 7, “Plan for future work,” and task 8, “Work on tools,” statistically significant differences are observed. For General Foremen task 2, “Plan/Prioritize Fallback Work with Foremen.”, statistically significant differences are observed.

A comparison of responses from traditional and AWP environment depicted differences in Foremen tasks 6, “Supervise/motivate/execute,” and task 10, “Moving crews to contingency work.” Similarly for General Foremen tasks 3 “Safety Related Activities,” task 4 “Constraint management,” and task 7 “Communication with field engineers” supported the research hypothesis. The results from surveys are also supported in interviews. Interview questionnaire is available at the end of this thesis as Appendix 6.

Categories including “Planning impediments to production- engineering deliverables” and “work package completeness” support the research hypothesis.

The research team believes that to effectively implement productivity is buffering techniques including AWP; it is imperative to understand where frontline supervisors spend their time. At an industry level, this research adds to an enormous opportunity for improvement, especially in today’s industrial construction projects.

LITERATURE REVIEW

The Construction Industry Institute defines Advanced Work Packaging as “A disciplined approach to improving productivity and predictability. It accomplishes this by aligning planning and execution activities across the project life cycle, from project setup to startup and turnover” (Construction Industry Institute 2013a). Figure 9 below illustrates the concept of AWP model which includes planning right from the project beginning during the front end planning and detailed engineering stages.

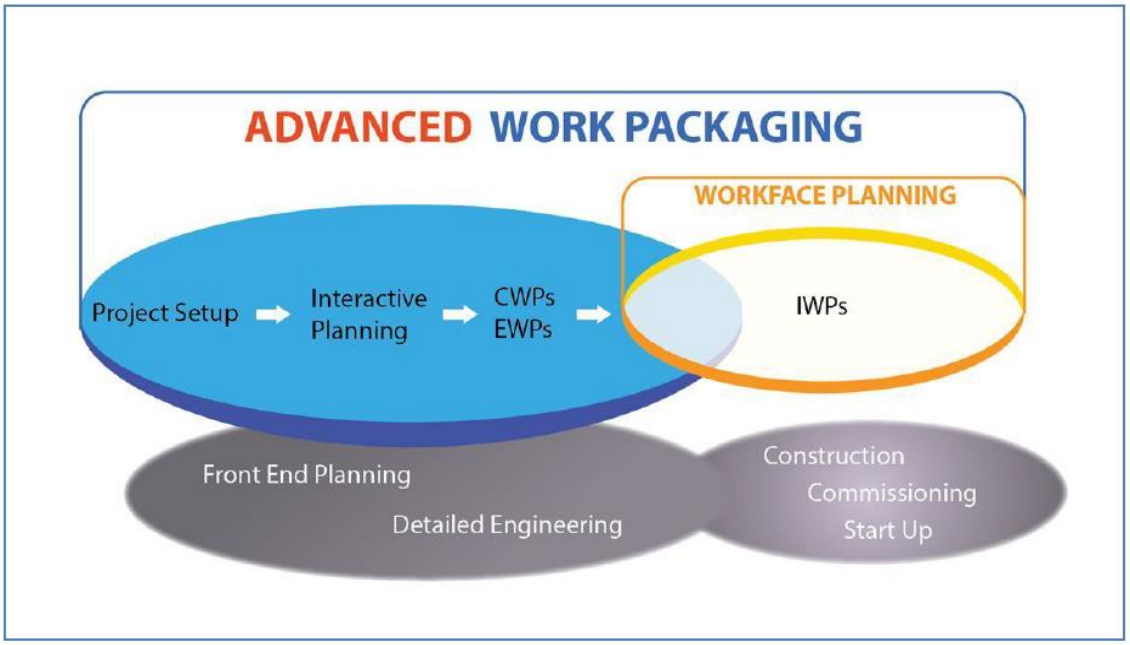


Figure 9 Concept of Advanced Work Packaging; Source: Construction Industry Institute: Advanced Work Packaging: Design through Workface Execution, Research Summary RT272-1, Version 2.1 (Construction Industry Institute 2013b).

The Construction Industry Institute further issued a case studies report in 2012 containing seven case studies and three expert interviews collected by the CII Research Team 272 Enhanced Work Packaging: Design through Work Face Execution (Construction Industry Institute 2013a). The projects and companies selected for review within this case studies report were within a range of industrial and commercial construction environments, including power, oil and gas, government, and commercial projects. High-level benefits including improved project part alignment and collaboration, site paperwork reduced, reduced rework, improved project cost and schedule, improved safety awareness and performance, more time for supervising, decreased supervisor and craft turnover, improved

labor productivity, increased reporting accuracy, enhanced turnover and improved client satisfaction, were observed (Meeks 2011).

The background literature on AWP establishes how AWP aimed towards improving productivity on industrial construction projects in Alberta oil sands construction projects. Some of the steps included delivering all resources necessary at the right time, to the right place, and to the right people to execute construction, to avoid cost overruns and delays. Other steps including relieving the onsite supervision team from the time-consuming tasks of onsite planning and resource tracking; thereby allowing them to focus on production and direction of their crews. These two measures explain that AWP helps in increasing construction productivity by pre-planning and reducing external impediments to production.

The research studies on AWP establish the importance of AWP in increasing the predictability and performance in industrial construction projects. However, as mentioned earlier, to effectively implement productivity buffering techniques, it is important to improve the performance of frontline supervisors. They are the first line of supervision and are directly responsible for production. However, little research is available on the impact of productivity enhancing practices including AWP on the performance of frontline supervisors. Hence, the research team analyzed the impact of AWP training on frontline supervisors in both traditional and AWP environments. They also compared the way frontline supervisors spend their time differently across the two production environments. This reasoning forms the basis of the research hypothesis to delve deeply into the impact of AWP. The research team believes that this effort would be useful to the industry and

educational practitioners to help industrial organizations to increase frontline productivity and performance.

RESEARCH QUESTIONS

Following the literature gap as explained above, the research team decided to analyze the impact of AWP training on industrial frontline supervisors. The researchers also compared the way frontline supervisors spend their time between the two production environments, traditional and AWP. The reasoning was to corroborate the research hypothesis by analyzing both traditional and AWP construction projects. The research team found it necessary to understand the influence of AWP training in traditional environments with lesser constraint management and pre-planning in comparison to AWP environments. They proposed at the beginning of research that frontline supervisors should perform differently in the two production environments. This lead to the main hypothesis of the research and research question "*Is there a difference in the time spent by frontline supervisors in traditional and AWP work environments? What is the influence of AWP training on the performance of frontline supervisors in industrial construction projects*?".

Further, they also presented that for each of the ten and eight Foremen and General Foremen tasks respectively, the differences should not be statistically significant. The explanation follows that some of the tasks are routine tasks that are performed on every industrial construction project irrespective of the production environment. For example, Foreman task 1: "Meetings," task 3: "Safety Related activities," the research team expected no statistically significant differences between the two populations. Similarly for General Foremen task 1: "Meetings," task 3: "Safety Related activities," task 8: "Completing

progress sheets," they expected that no difference should exist. This lead to the sub hypothesis of the research *"Of the ten and eight proposed tasks for Foremen and General Foremen respectively, for tasks common to any construction environment including tasks 1 and 3 for Foremen and tasks 1,3, and 8 for General Foremen, are the differences between the populations statistically significant?"*

Next, the research team expected for Foremen tasks involving planning and prioritizing, coordinating, supervising and motivating, and contingency planning, differences should exist between the two populations. Similarly, for General Foremen tasks including planning and prioritizing, following up, work package development, and communication with field engineers, statistically significant differences should exist. This lead to the next sub hypothesis of the research *"For Foremen tasks including task 2,5,6,7, and 10, and for General Foremen tasks including task 2,4,6, and 7, are the differences between the populations statistically significant?"*The next section would provide the research methodology adopted by the research team to validate the research hypothesis and sub hypotheses.

RESEARCH METHODOLOGY

The crucial tasks and proposed time ranges are defined in thesis chapter 3 and Appendices 2 and 3. Foremen and General Foremen tasks already defined in chapter 3 are again presented as Tables 16 and 17 below to maintain the flow of this chapter. Building on the crucial tasks already defined, this chapter along with establishing the time spent by frontline supervisors in traditional and AWP environments, compares their responses to establish statistical differences. Following the research hypothesis and sub hypotheses

defined in the previous section, the research team started analyzing the survey data to compare the different populations.

Table 16 Foremen tasks during a "Productive Day"- Ideal ranges

Task	**Minutes/Hours Per Day Spent**		
1. Meetings – Client/Coordination/Scheduling/Look Ahead	15-60 mins.	1.5-2 hrs.	2-4 hrs.
2. Plan/Prioritize Tasks & Fallback Work (Plan "B")	0-30 mins.	45-90 mins.	2-3 hrs.
3. Safety Related Activities – Meetings/JHA Development/Inspections/Action Items/Sign/Review FLHAs	0-15 mins.	30-60 mins.	1.5-3 hrs.
4. Complete Paperwork	10-25 mins.	30-60 mins.	65-90 mins.
5. Coordinate with other Crews/Support	0 mins.	5-15 mins.	16-25 mins.
6. Supervise/Motivate/Execute	4 hrs. or less	5-6 hrs.	8 hrs. or more
7. Plan for Future Work	15-35 mins.	45-1.25 hrs.	1.5-2 hrs.
8. Work on Tools with Crew	0-15 mins.	15-45 mins.	1-2 hrs.
9. Receive/Check/Verify Materials in Area	0 mins.	5-15 mins.	16-25 mins.
10. Move Crews to Contingency Work	0 mins.	5-15 mins.	16-25 mins.

Table 17 General Foremen tasks during a "Productive Day"- Ideal ranges

Task	Minutes/Hours Per Day Spent		
1. Meetings – Client/Coordination/Scheduling/Look Ahead	15-60 mins.	1.5-2 hrs.	2-4 hrs.
2. Plan/Prioritize Tasks & Fallback Work (Plan "B") with Foremen	0-30 mins.	45-90 mins.	2-3 hrs.
3. Safety Related Activities – Meetings/JHA Development/Inspections/Action Items/Sign/Review FLHAs	0-15 mins.	30 -60 mins.	1.5-3 hrs.
4. Constraint Mgt. – Ensure FM has all Crane support/crane/scaffold/Material/Equipment	0-30 mins.	60-90 mins.	2-3 hrs.
5. Follow up with FM & Crews Throughout Day – Work Area Reviews/Productivity Check in Field	30-45 mins.	1.5-3 hrs.	4-6 hrs.
6. Work Package Development – Model Review/FIWP Review/FIWP Schedule/Close-Out FIWPs	0-30 mins.	1-2 hrs.	3-4 hrs.
7. Communicate with Field Engineers – Develop Estimates for Extra Work/RFIs	0-15 mins.	30-60 mins.	1.5-3 hrs.
8. Complete Progress/Timesheets/Forecasts/Review Installed Quantities/Cost Codes	0-15 mins.	30-60 mins.	1.5-3 hrs.

The data collection efforts commenced with distributing paper based surveys across industrial sites in North America. A mixture of construction environments and industrial sectors was maintained to compare the different responses and establish the research hypothesis. Representatives were contacted on industrial sites in North America to recruit

them to distribute surveys to their frontline supervisors on their respective industrial sites. It is important to mention here the researchers knew the organizational structure and the kind of construction environment on each of the construction sites. The details on the organizational structure of the projects under consideration are provided in the below sections.

After the completion of data collection, the third stage involved analyzing and comparing responses from traditional and AWP environments. The researchers also proposed to include only the following trades in the analysis: Iron Worker, Mechanical/Millwright, Pipefitter, Pipefitter Welders, Electrical/Instruments, Carpenter/Scaffolder, and Boilermaker. The reasoning follows is they are the primary beneficiaries of AWP as well as drivers of construction productivity. The researchers decided to exclude the data from support and related crafts.

Also, the research team compared the responses of respondents in two production environments by conducting face to face interviews involving questions related to productivity impediments and daily tasks. The researchers believes that this effort is important to support the survey results qualitatively. The researchers found that respondents in AWP environemnts gave more focussed answers and faced lesser productivity impediments in comparison to their traditional counterparts. The next section would elaborate in detail the analysis approach including number of respondents and explanation to include the particular analysis.

CONTENT

To elaborate on the influence of AWP on the performance of frontline supervisors, the researchers divide their analysis into two parts. The researchers firstly established the influence of AWP training on frontline supervisors in traditional and AWP Projects. To ascertain whether the respondents received training in AWP or not, the survey included the question "Have you had training in any of the following areas (check all that apply): Safety, Quality Control, Scheduling, Estimating, Supervisory Skills, 3D/BIM Model, Effective Communication, AWP/WFP, Time Management, Lean Construction, and Time Motion Studies". Even though the survey asked the respondents whether or not they received training in each of the areas above, this chapter focuses on only AWP training. The researchers isolated the impact of training by conducting Chi-Squared analysis on a group of Traditional and AWP projects, separately for the crafts above. The chi-squared test is used to establish statistical independence between categorical variables of two or more groups, by establishing the p-value based on the Chi-squared statistic generated on their comparison. The researchers have presented results for those tasks in which the corresponding p-value was less than or equal to 0.10. Results for four groups have been presented in this chapter: Foremen in Traditional projects with and without AWP training (294 Foremen, 38 with AWP training), General Foremen in Traditional projects with and without AWP training (124 General Foremen, 27 with AWP training), Foremen in AWP projects with and without AWP training (157 Foremen, 42 with AWP training), and General Foremen in AWP projects with and without AWP training (42 General Foremen, 23 with AWP training).

In addition to ascertaining the impact of training on frontline supervisors in traditional and AWP environments, the researchers investigated the differences in how the frontline supervisors allocate their time across tasks in these two execution methods. The survey data for AWP projects stems from two large industrial projects. Of these two AWP projects, one project was facing significant materials delays, as informed by the representative who was recruited to conduct the survey on that particular industrial construction job site. The researchers agree that the ability to distinguish between successful and problematic AWP projects allows for further analysis to ascertain how external productivity impediments can hamper the performance of AWP projects. Traditional projects sampled were considered to be performing well for traditional execution practices. After compiling the responses from AWP and traditional projects, the researchers compared the responses for each task for foremen and general foremen between all AWP and Traditional projects to determine differences between the samples. As already stated above, one of the AWP source projects was sampled at a time when the project was facing several external impediments that were causing significant disruptions to the site activities. The researchers decided to repeat the chi-squared analysis by removing that one project from the comparative sample- to support the ideology of AWP, external impediments including material problems are not a characteristic of effective AWP execution. The researchers then performed analysis on the smaller sample size of AWP projects with 89 Foremen and 20 General Foremen. The researchers have presented results for those tasks in which the corresponding p-value was less than or equal to 0.10. As mentioned above, the researchers limited the investigation to the following crafts:

Ironworkers, Mechanical/Millwrights, Pipefitters, Pipefitter/Welders. Electrical/Instruments, Carpenter/Scaffolders, and Boilermakers. For this analysis, on the AWP projects there were 156 Foremen and 42 General Foremen, and for the Traditional Projects, there were 294 Foremen and 124 General Foremen.

Along with illustrating the influence of AWP on the performance of frontline supervisors by performing statistical analysis on the two groups of frontline supervisors. This chapter presents the results of 113 case study interviews of frontline supervisors across 9 industrial sites spread demographically in the US. The interviews were administered in person on industrial sites in Alabama, Louisiana, Tennessee, and Texas. Quotes from interviews are presented to illustrate the difference in execution environments and external impediments to production in AWP and traditional construction environments. The sections below elaborate on the results of statistical analysis of surveys along with presenting a qualitative analysis of the case study interviews.

RESULTS

As discussed above, the analysis presented in this chapter is divided into two parts. The first part would illustrate the importance of AWP training on frontline supervisors in AWP and traditional projects separately. It is done to isolate the impact of AWP in traditional projects separately, with comparatively lesser constraint management and advanced pre-planning. The second part would illustrate the difference between the time spent by frontline supervisors in traditional and AWP environments by comparing the two groups statistically and establishing differences from the proposed time ranges by the researchers.

To illustrate the influence of AWP on industrial frontline supervisors, the researchers

performed Chi-squared analysis on the two group of responses, one with AWP training and one without AWP training for both Traditional and AWP projects. It is important to note here that the survey did not ascertain the extent of training. However, the researchers are aware that typically training lasts for ½ to 1 day in industrial organizations. The following sections below would elaborate on the influence of AWP training on frontline supervisors in traditional and AWP projects separately.

AWP Training on Traditional Projects

To isolate the impact of AWP training on the performance of frontline supervisors, apart from other aspects of AWP implementation, the researchers focused on the impact of training on supervisors in AWP and traditional environments. When Chi-squared analysis was performed on the group of frontline supervisors with and without AWP training on traditional projects, 4 Foremen tasks and 2 General Foremen tasks were found to be statistically different in the two groups. Foremen tasks including Task 2: Plan/Prioritize task and fallback work (Plan "B"), Task 5: Coordinate with other crews/support, Task 9: Check and verify materials, and Task 8: Time on tools, showed statistical differences on a comparison between the two groups (No statistically significant differences were seen on other tasks). Tables 18,19,20, and 21 below show the number of respondents, expected counts, relative frequencies, χ^2 value, and p-value for two categories of respondents, one with AWP training and one without AWP training. Columns 1,4, and 7 are the counts of respondents in each of the three categories recorded in the surveys. Columns 2,5, and 8 are the expected counts for statistical independence. Columns 3,6, and 9 are the percentages of respondents in each of the three categories.

Table 18 Task 2- Plan/prioritize tasks and fallback work, traditional projects

	Time Range -A			Time Range -B			Time Range -C			
	1	2	3	4	5	6	7	8	9	Count
Training	12	18.3	31.6%	22	17.8	57.9%	4	1.8	10.5%	38
No Training	129	122.7	50.8%	115	119.2	45.3%	10	12.2	3.9%	254
Count	141			137			14			292
$\chi 2$ value		6.641			p value			0.036		

Table 19 Task 5- Coordinate with other crews, traditional projects

	Time Range -A			Time Range -B			Time Range -C			
	1	2	3	4	5	6	7	8	9	Count
Training	0	0.9	0.0%	9	17.3	23.7%	29	19.8	76.3%	38
No Training	7	6.1	2.8%	124	115.7	48.8%	123	132.2	48.4%	254
Count	7			133			152			292
$\chi 2$ value		10.572			p value			0.005		

Table 20 Task 9- Check Materials, traditional projects

	Time Range -A			Time Range -B			Time Range -C			
	1	2	3	4	5	6	7	8	9	Count
Training	0	1.0	0.0%	8	14.3	21.1%	30	22.6	78.9%	38
No Training	8	7.0	3.1%	104	97.7	40.2%	147	154.4	56.8%	259
Count	8			112			177			297
$\chi 2$ value		7.118			p value			0.028		

Table 21 Task 8- Time on tools, traditional projects

	Time Range -A			Time Range -B			Time Range -C			
	1	2	3	4	5	6	7	8	9	Count
Training	24	14.6	63.2%	7	13.6	18.4%	7	9.8	18.4%	38
No Training	90	99.4	34.9%	99	92.4	38.4%	69	66.2	26.7%	258
Count	114			106			76			296
$\chi 2$ value		11.450			p value			0.003		

Figures 10,11,12, and 13 depict the difference in responses between the two groups for the above tasks graphically. As shown in Figure 10 below, on Task 2- Plan/Prioritize Tasks and Fallback Work (Plan "B"), those with training spend more time on this task than those with no training (p-value 0.036). Figure 11 below illustrates the results for Foremen

on task 5- Coordinate with other crews/support. Foremen with training are seen to be spending more time on this task than those with no training (p-value of 0.005). Figure 12 below illustrates the results for foremen on Task 12- Receive/check/verify materials in the area. As with tasks 2 and 5, Foremen with training spend more time on this task than those with no training (p-value of 0.028). These three results indicate that Foremen with training on an average spend more time than what was proposed to be the targeted range by the researchers. Researchers always understand that the difference might be a function of working on traditional projects where there is less constraint management than on AWP projects.

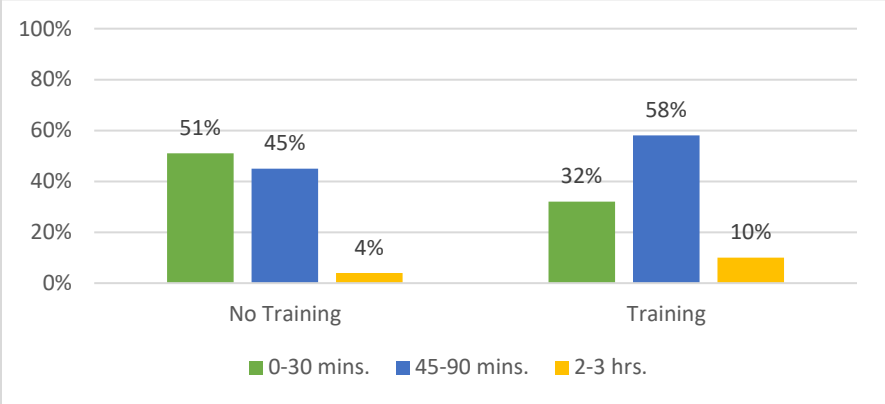


Figure 10 Foremen time allocation by percentage on Task 2- Plan/prioritize task and fallback work, traditional projects

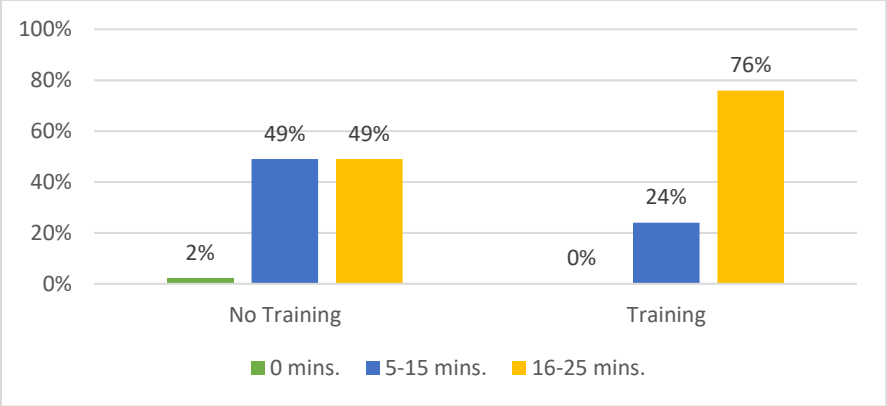


Figure 11 Foremen time allocation by percentage on Task 5- Coordinate with other crews, traditional projects

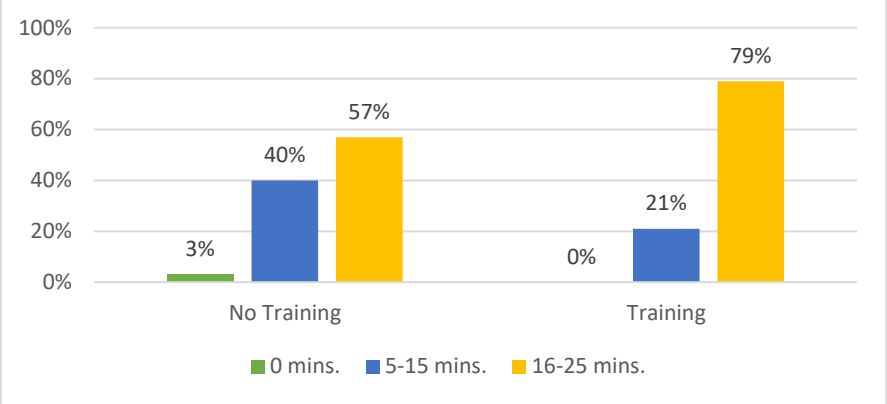


Figure 12 Foremen time allocation by percentage on Task 9 – check materials, traditional projects

The additional time that AWP trained Foremen to spend on tasks 2,5, and 9 is counterbalanced by a reduction of time spent on Task 8- Work on tools with the crew. Figure 13 below compares the percentage of time spent on the task for foremen with and without training (p-value of 0.003). Hence, the researchers conclude for foremen, that the findings are consistent with AWP principles- prioritize, plan, remove constraints, and spending more time making sure that the crew is productive.

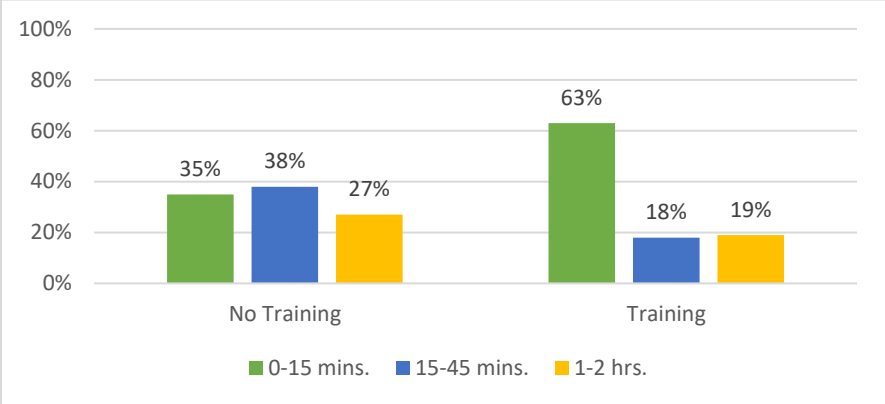


Figure 13 Foremen time allocation by percentage on Task 8 – time on tools, traditional projects

General Foremen tasks including Task 2: Plan/Prioritize task and fallback work (Plan "B") with Foremen, Task 5: Coordinate with other crews, Task 6: Work Package development- Model Review/FIWP Review/FIWP Schedule/ Close-Out FIWP, illustrate statistically significant differences for General Foremen with and without AWP training (No statistically significant differences were seen on other tasks). Tables 22 and 23 below show the number of respondents, expected counts, relative frequencies, χ^2 value, and p-value for two categories of respondents, one with AWP training and one without AWP training.

Table 22 General Foremen time allocation by percentage on Task 2 – Plan/Prioritize, traditional projects

	Time Range -A			Time Range -B			Time Range -C			
	1	2	3	4	5	6	7	8	9	Count
Training	5	11.1	18.5%	13	8.5	48.1%	9	7.4	33.3%	27
No Training	46	39.9	47.4%	26	30.5	26.8%	25	26.6	25.8%	97
Count	51			39			34			124
$\chi 2$ value		7.789`			p value			0.020		

Table 23 General Foremen time allocation by percentage on Task 6 – Work Package Development, traditional projects

	Time Range -A			Time Range -B			Time Range -C			
	1	2	3	4	5	6	7	8	9	Count
Training	5	9.7	18.5%	12	13.7	44.4%	10	3.6	37.0%	27
No Training	38	33.3	40.9%	49	47.3	52.7%	6	12.4	6.5%	93
Count	43			61			16			120
$\chi 2$ value		17.876			p value			0.0001		

Figures 14 and 15 depict the difference in responses between the two groups for the above tasks graphically. As shown in Figure 13 below, on Task 2- Plan/Prioritize Tasks

and Fallback Work (Plan "B") with Foremen, those with training spend more time closer to the ideal than those without training (p-value of 0.02). Figure 14 below illustrates the results for General Foremen on Task 6- Work Package Development, those with training spend more on work package development and review (p-value of 0.0001).

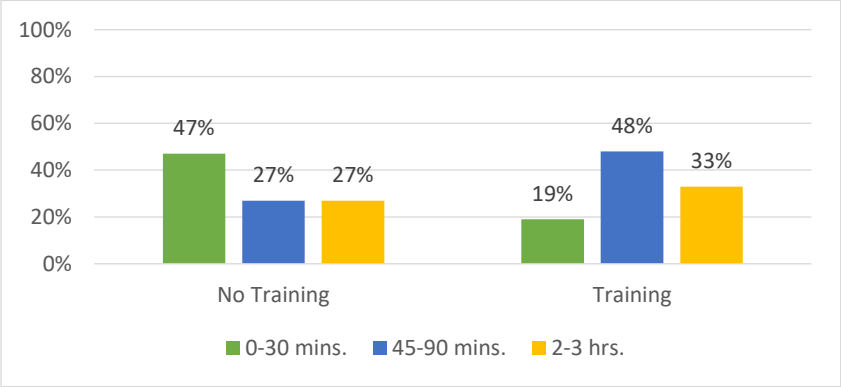


Figure 14 General Foremen time allocation by percentage on Task 2 – Plan/prioritize fallback work, traditional projects

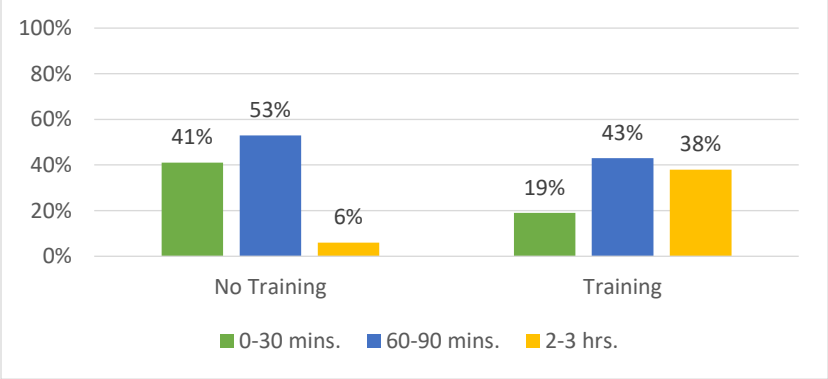


Figure 15 General Foremen time allocation by percentage on Task 6- Work Package Development, traditional project

Hence for traditional projects, frontline supervisors with AWP training were found to time spend time more effectively in comparison to frontline supervisors without AWP training. The next sections would illustrate the impact of AWP training on AWP projects.

AWP Training on AWP projects

The analysis above presents a strong overview of the impact of AWP training within a traditional execution context. This section will illustrate the impact of AWP training on frontline supervisors in AWP projects. The reasoning behind performing the analysis separately for both AWP and traditional environments is to gauge if there are substantive differences between the two production environments. The researchers expected that there would be lesser differences within the frontline supervisors with and without training in AWP environments, because they are operating within an AWP environment. For the crafts above, the analysis was performed on a sample of 157 Foremen (42 with AWP training) and 42 General Foremen (23 with AWP training). After segregating the two responses in two groups, one with and one without training, the researchers observed statistically significant differences in how these groups spend their time on three tasks- 2 for Foremen and 1 for General Foremen.

To isolate the impact of AWP training on the performance of frontline supervisors in AWP environments, the researchers performed the Chi-Squared analysis on the two groups. Two Foremen tasks and one General Foremen task were found to be statistically different (no statistical difference for other tasks). Foremen tasks including Task 7: Plan for Future Work and Task 8: Work on tools with the crew, showed statistical differences. Tables 24 and 25 below show the number of respondents, expected counts, relative

frequencies, χ^2 value, and p-value for two categories of respondents, one with AWP training and one without AWP training. Columns 1,4, and 7 are the counts of respondents in each of the three categories recorded in the surveys. Columns 2,5, and 8 are the expected counts for statistical independence. Columns 3,6, and 9 are the percentages of respondents in each of the three categories.

Table 24 Foremen time allocation by percentage on Task 7 – Plan for future work, AWP projects

	Time Range -A			Time Range -B			Time Range -C			
	1	2	3	4	5	6	7	8	9	Count
Training	6	11.8	15.4%	27	19.4	69.2%	6	7.8	15.4%	39
No Training	41	35.2	35.3%	50	57.6	43.1%	25	23.2	21.6%	116
Count	47			77			31			155
χ2 value		8.400			p value			0.015		

Table 25 Foremen time allocation by percentage on Task 8 – Work on tools, AWP projects

	Time Range -A			Time Range -B			Time Range -C			
	1	2	3	4	5	6	7	8	9	Count
Training	28	18.9	70.0%	9	13.8	22.5%	3	7.4	7.5%	40
No Training	46	55.1	39.3%	45	40.2	38.5%	26	21.6	22.2%	117
Count	74			54			29			157
$\chi 2$ value		11.660			p value			0.003		

Figures 16 and 17 depict the difference in responses between the two groups for the above tasks graphically. As shown in Figure 15 below, on Task 7- Plan for Future work, those with training spend more time closer to the ideal than those without training (p-value of 0.015). This is particularly a positive influence for Foremen spending less than the ideal time, a shift of 20 %. Figure 16 below illustrates the results for Foremen on Task 8- Work on tools with the crew, those with training indicate a considerable shift to less time spent on tools with the crew, a result that is less than the proposed ideal range by the researchers. This finding was found to be consistent with the principle of AWP execution, AWP emphasizes on planning for productivity and removing constraints and ensuring the crew is productive.

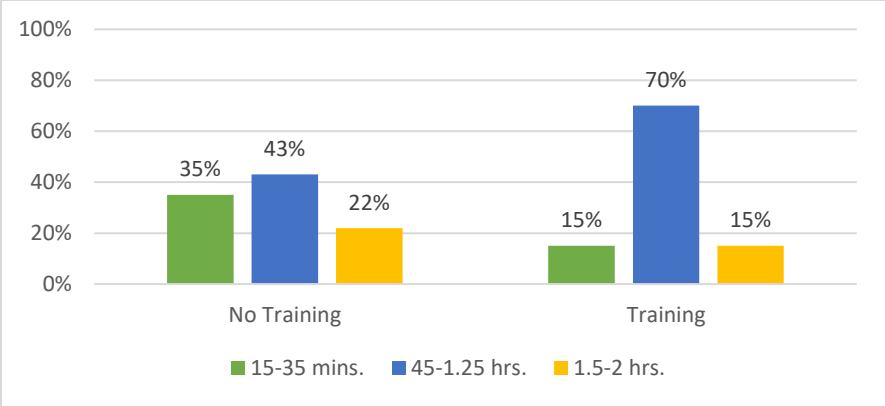


Figure 16 Foremen time allocation by percentage on Task 7- Plan for Future work, AWP Projects

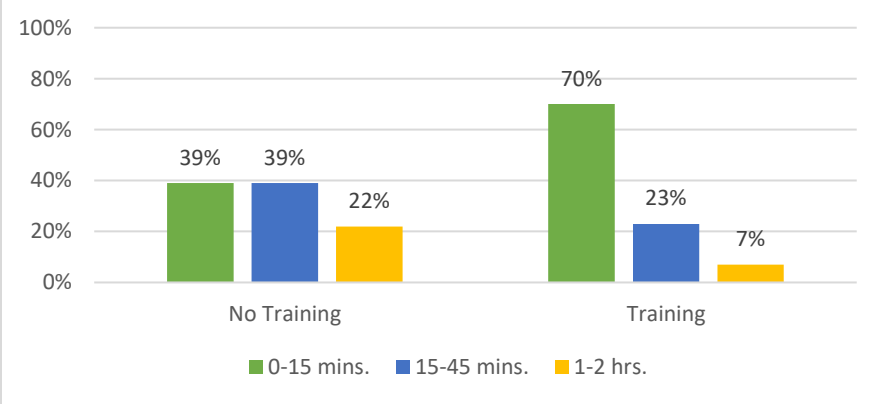


Figure 17 Foremen time allocation by percentage on Task 8- Work on Tools with the Crew, AWP Projects

For General Foremen task 2- Plan/Prioritize Tasks and Fallback Work with Foremen showed statistical differences. Table 26 below show the number of respondents, expected counts, relative frequencies, χ^2 value, and p-value for two categories of respondents, one with AWP training and one without AWP training.

Table 26 General Foremen time allocation by percentage on Task 2 –Plan/Prioritize Tasks and Fallback work with Foremen, AWP projects

	Time Range -A			Time Range -B			Time Range -C			
	1	2	3	4	5	6	7	8	9	Count
Training	4	6.8	21.1%	14	10.4	73.7%	1	1.8	5.3%	19
No Training	11	8.2	47.8%	9	12.6	39.1%	3	2.2	13.0%	23
Count	15			23			4			42
$\chi 2$ value		5.018			p value			0.081		

Figure 18 below depicts the difference between two groups, one with training and one without training. General Foremen with training spend considerably more time with their foremen than those who do not; the responses are also observed to be closer to the target ranges as defined by the researchers. As presented above, this result is consistent with the findings supported in traditional projects.

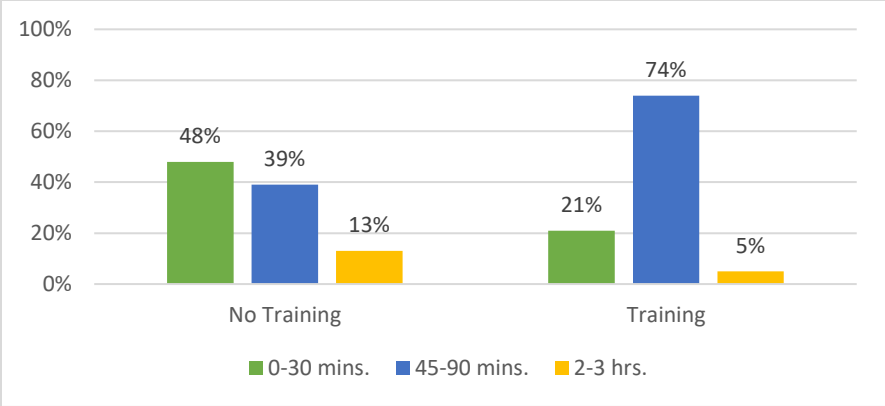


Figure 18 General Foremen time allocation by percentage on Task 2- Plan/prioritize tasks/ fallback work with Foremen, AWP Projects

Along with presenting tests of statistical significance for comparison between the two groups on the influence of AWP training on the frontline supervisors in both traditional and AWP environments, this chapter presents results comparing the way frontline supervisors divide their time in AWP and traditional execution environments. This section allows investigation of differences of how Foremen and General Foremen allocate their time across tasks in the two execution environments. AWP is found to make a meaningful difference in how Foremen and General Foremen spend their time on projects.

As already stated above, out of the two AWP projects studied in this chapter, one project was facing significant materials delays, and hence the project is not performing very well. The site representative who was recruited in the study to collect responses from frontline supervisors on that site confirmed it. The investigation is limited to the crafts mentioned above: Iron Workers, Mechanical/Millwrights, Pipefitters, Pipefitter Welders, Electrical/Instruments, Carpenter/Scaffolders, and Boilermakers. Firstly, the analysis was performed to compare the responses from traditional and both the AWP projects combined.

By removing the project that was facing material problems, the sample size for AWP comparison that is presented in this chapter is 89 Foremen and 20 General Foremen.

Tables 27 and 30 lists the results of the analysis for Foremen and General Foremen for each of the 10 and 8 tasks respectively. The following criteria were used to screen the differences between the two samples: 1) p-value <.1, indicating a 90 % chance that the samples are meaningfully different. 2) p-value <.2, indicating an 80 % chance that samples are meaningfully different. It is not accepted in construction research; however, the researchers have used this analysis to likely identify the differences between the two samples. 3) A 10 % or greater difference between the number of respondents on at least one of the three samples. It was found particularly important in smaller sample sizes, particularly true after removing the AWP project facing external material impediments. The validity of chi-squared statistic does not hold true when the expected count in either of the three categories is less than 4.

Each table indicates if the Chi-squared test found a difference between the two samples of AWP and Traditional, and AWP (adjusted) and Traditional for each task. The p-value is provided for each of the tasks that meet at least one of the three criteria mentioned above. The results are presented using the following acceptable criteria: 1) Both comparisons meet screening criteria 1 (p-value less than .1), the result is *strongly supported*. 2) One comparison meets criteria 2 (p-value less than .2), and other comparison meets criteria 1 (p-value less than .1), the result is *supported*. 3) One comparison meets criteria 1, and another comparison has no statistical significance, the result is *weakly*

supported. 4) Both comparisons meet any of the three screening criteria, the result is *possible*. 5) One of the comparisons has p-value between .2 and .1, the result is *possible*.

Foremen

Table 27 below indicates that Foremen have three tasks that are partially supported and two tasks are supported. Supported tasks are Task 6- Supervise/motivate and execute, and Task 10- Move crews to contingency work. Findings for Task 6 indicate a shift towards more time spent in the field in AWP environments. Tables 28 and 29 below show the number of respondents, expected counts, relative frequencies, χ^2 value, and p-value for two categories of respondents, one in the traditional execution environment and one in adjusted AWP environment.

On task 10, AWP shows a reduction of time spent in moving crews to contingency work. This finding is consistent with the hypothesis of this chapter. Table 29 below show the number of respondents, expected counts, relative frequencies, χ^2 value, and p-value for two categories of respondents, one in the traditional execution environment and one in adjusted AWP environment.

Table 27 Foremen- Difference between AWP and Traditional Time on Tasks

Foremen Task	AWP vs. Traditional	AWP(adjusted) vs. Traditional	Difference?
1	X	X	
2	X	X	
3	X	Y (p=.026)	Weakly Supported
4	X	Y (p=.004)	Weakly Supported
5	X	Y (p=.029)	Weakly Supported
6	Y (p=.19)	Y (p=.056)	Supported
7	X	Y (p=.127)	Possible
8	Y (p=.12)	X	Possible
9	X	Y (p=.14)	Possible
10	Y (p=.14)	Y (p=.042)	Supported

Table 28 Foremen time allocation by percentage on Task 6 –Supervise/Motivate/and Execute, AWP vs. Traditional

	Time Range -A			Time Range -B			Time Range -C			
	1	2	3	4	5	6	7	8	9	Count
Training	79	70.7	26.7%	101	103.0	34.1%	116	122.2	39.2%	296
No Training	13	21.3	14.6%	33	31.0	37.1%	43	36.8	48.3%	89
Count	92			134			159			385
χ2 value		5.732			p value			0.056		

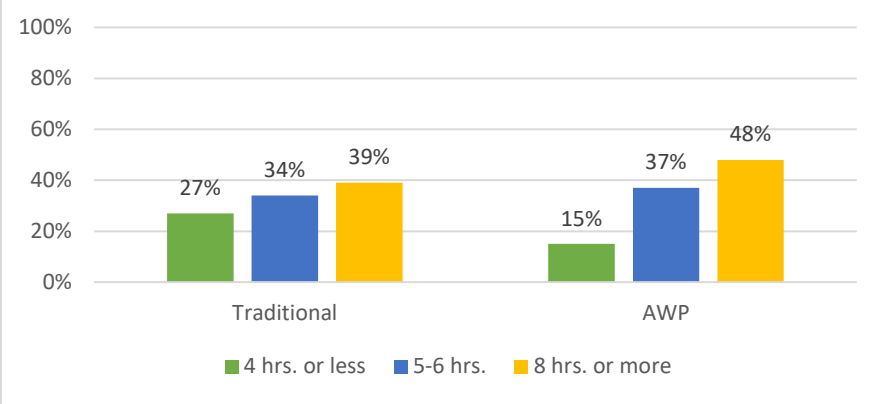


Figure 19 Foremen time allocation by percentage on Task 6 –Supervise/Motivate/and Execute, AWP vs. Traditional

Table 29 Foremen time allocation by percentage on Task 10 –Move crews to contingency work, AWP vs. Traditional

	Time Range -A			Time Range -B			Time Range -C			
	1	2	3	4	5	6	7	8	9	Count
Training	17	20.0	5.7%	147	153.4	49.7%	132	122.6	44.6%	296
No Training	9	6.0	10.2%	52	45.6	59.1%	27	36.4	30.7%	88
Count	26			199			159			384
χ2 value		6.349			p value			0.042		

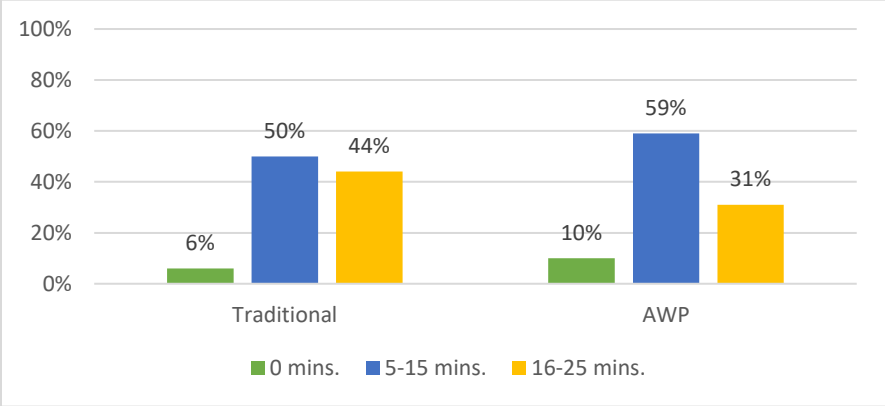


Figure 20 Foremen time allocation by percentage on Task 10 –Move crews to contingency work, AWP vs. Traditional

Table 30 below provides evidence that on AWP and traditional projects General Foremen spend their time differently. For General Foremen, three out of the eight tasks are supported or strongly supported to illustrate differences between traditional and AWP environments. For tasks 3,4, and 7 respectively related to Safety Related activities, constraint management and communication with the field engineers the results illustrate

that General Foremen in AWP environments have evidence of performing effectively than their counterparts in traditional environments. Table 31 and Figure 21 below show that on AWP projects, General foremen spend less time on safety related activities such as meetings, and JHA development etc. A perception of the researchers is that crews tend to review safety buzzwords, recite safety pledges, and listen to their supervisor's review or recite information that has been passed down from management. Safety related activities should not be done for safety's sake; rather, safety activities should be incorporated into the overall work plan and tasks and should be specific to work at hand. AWP's incorporation of safety planning into IWPs (Installation Work Packages) and AWP's constraint analysis to minimize work performed out of sequence supports an inference that on AWP, GFs can spend less time on safety items that are called out in daily routines and focus more on planning and supervising the work at hand and include safety considerations into that planning.

Table 30 General Foremen- Difference between AWP and Traditional Time on Tasks

General Foremen Task	AWP vs. Traditional	AWP (adjusted) vs Traditional	Difference?
1	X	X	
2	Y (p=.23)	Y (p=.129)	Possible
3	Y (p=.16)	Y (p=.028)	Supported
4	Y (p=.08)	Y (p=.043)	Strongly Supported
5	X	Y (p=.16)	Possible
6	X	Y (p=.18)	Possible
7	Y (p=.14)	Y (p=.034)	Supported
8	Y (p=.25)	Y (p=.131)	Possible

Table 31 General Foremen time allocation by percentage on Task 3 –Safety Related activities, AWP vs. Traditional

	Time Range -A			Time Range -B			Time Range -C			
	1	2	3	4	5	6	7	8	9	Count
Training	14	17.2	11.3%	93	92.1	75.0%	17	14.6	13.7%	124
No Training	6	2.8	30.0%	14	14.9	70.0%	0	2.4	0.0%	20
Count	20			107			17			144
$\chi 2$ value		7.141			p value			0.028		

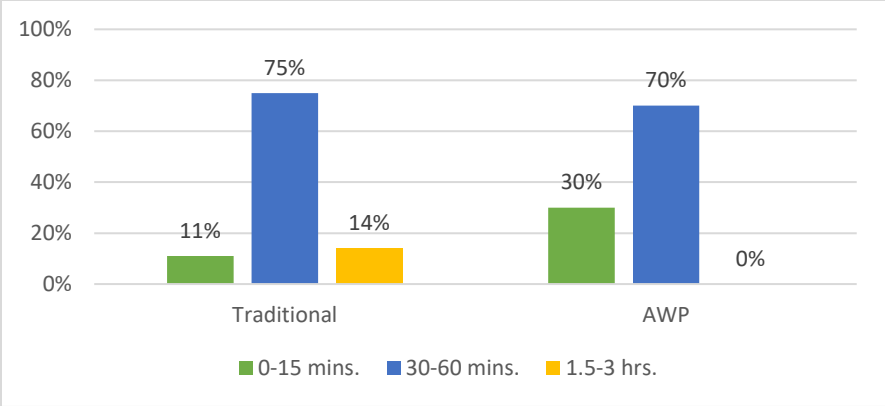


Figure 21 General Foremen time allocation by percentage on Task 3 –Safety Related activities, AWP vs. Traditional

For General Foremen tasks 4 and 7 being constraint management and communication with the field engineers respectively, it can be seen in Table 32 and Figure 22 for Task 4- constraint management and in Table 33 and Figure 23 for Task 7- communication with field engineers that General Foremen in AWP environments spend more time on constraint management and communication with the field engineers than in traditional environments. The results show that the General Foremen averages are closer to the proposed targeted ranges as presented by the researchers (middle column). It is imperative to help foremen and their crews to be more productive.

Table 32 General Foremen time allocation by percentage on Task 4 –Constraint management, AWP vs. Traditional

	Time Range -A			Time Range -B			Time Range -C			
	1	2	3	4	5	6	7	8	9	Count
Training	62	59.3	50.8%	46	50.7	37.7%	14	12.0	11.5%	122
No Training	7	9.7	35.0%	13	8.3	65.0%	0	2.0	0.0%	20
Count	69			59			14			142
χ2 value		6.261			p value			0.043		

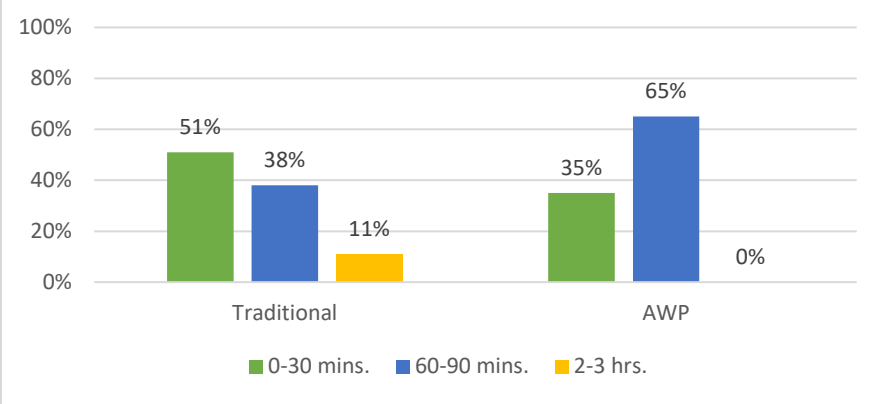


Figure 22 General Foremen time allocation by percentage on Task 4 –Constraint management, AWP vs. Traditional

Table 33 General Foremen time allocation by percentage on Task 7 –Communication with Field Engineers, AWP vs. Traditional

	Time Range -A			Time Range -B			Time Range -C			
	1	2	3	4	5	6	7	8	9	Count
Training	32	31.2	26.0%	63	67.6	51.2%	28	24.3	22.8%	123
No Training	4	4.8	21.1%	15	10.4	78.9%	0	3.7	0.0%	19
Count	36			78			28			142
$\chi 2$ value		6.789			p value			0.034		

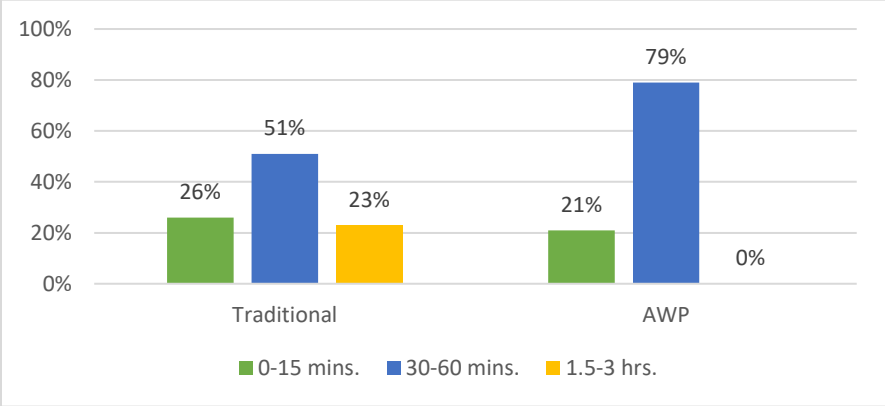


Figure 23 General Foremen time allocation by percentage on Task 7 –Communication with Field Engineers, AWP vs. Traditional

Also, for General Foremen Task 6 (Table 34 and Figure 24), the survey results show that the General Foremen in AWP environments spend more time in work package development and review than in traditional projects. However, the result is not supported statistically as for AWP adjusted sample, one of the expected counts is less than 4.

Table 34 General Foremen time allocation by percentage on Task 6 –Work package development, AWP vs. Traditional

	Time Range -A			Time Range -B			Time Range -C			
	1	2	3	4	5	6	7	8	9	Count
Training	45	41.4	37.5%	65	68.2	54.2%	10	10.4	8.3%	120
No Training	3	6.6	15.8%	14	10.8	73.7%	2	1.6	10.5%	19
Count	48			79			12			139
χ2 value		3.429			p value			0.18		

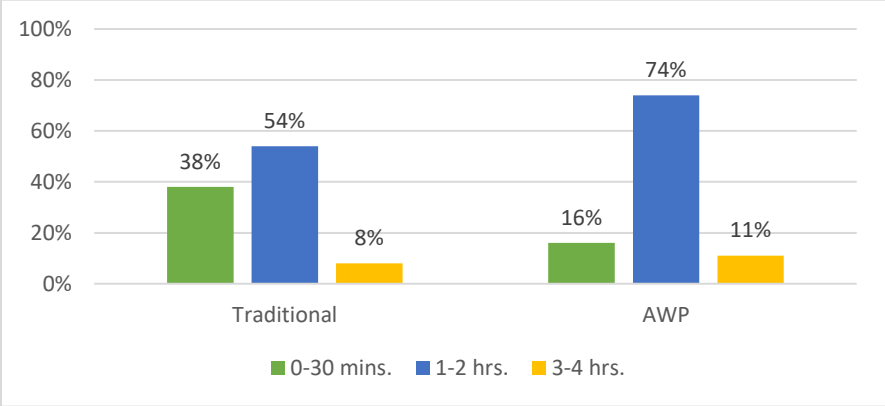


Figure 24 General Foremen time allocation by percentage on Task 6 –Work package development, AWP vs. Traditional

Other findings for General Foremen are that there is a possible significance on tasks 2: Plan/Prioritize Fallback Work,5: Follow up with Foremen, and 8: Complete timesheets. While not reaching a level of statistical significance, for Task 2 - Plan/prioritize tasks and fallback work with foremen, General Foremen spend less time on AWP projects and less

time than the ideal (Figure 25). It may be due to improved planning and constraint management, requiring less contingency planning. On Task 5 – Follow up with Foremen and crews, there is a shift with General Foremen spending more time following up with Foremen throughout the days on the adjusted AWP data, but this is not seen on the larger set. The researchers also agree that this result might be due to the smaller data sample for adjusted AWP project. For Task 8 - complete progress reports/timesheets, the General Foremen on AWP projects note some shift towards the ideal compared to traditional projects. This may be due to more structured approaches to AWP discipline.

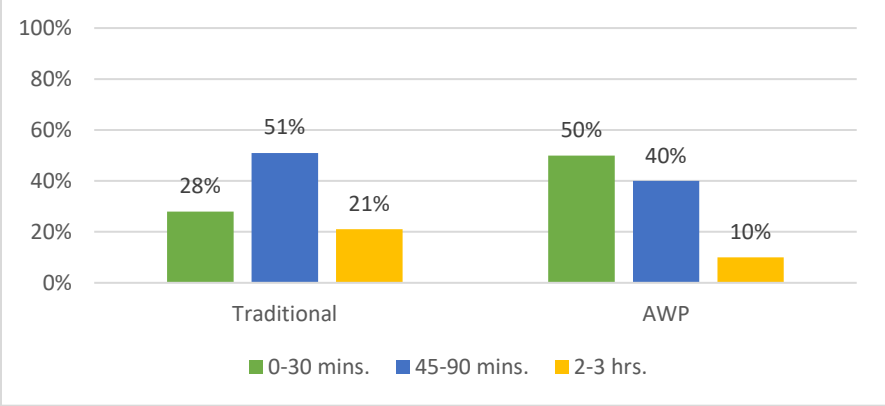


Figure 25 General Foremen time allocation by percentage on Task 2 – Prioritize tasks and fallback work, AWP vs. Traditional

This chapter aims to justify that the frontline supervisors in AWP environments spend time more effectively in comparison to their counterparts in traditional environments. The evidence of lesser external impediments and more constraint management were also observed during the case study interviews administered on both traditional and AWP project sites in the US. The section below would compare quotes from

frontline supervisors in traditional and AWP environments to qualitatively support the findings of surveys.

When frontline supervisors were interviewed on industrial sites in North America, evidence that supports the fact that Advanced Work Packaging enables better constraint management and helps to improve the performance of frontline supervisors surfaced. Of total 9 sites on which the interviews were conducted, 2 implemented AWP practices, 3 implemented traditional practices, and 4 were maintenance and rehabilitation sites. As far as the industrial sector is concerned, 3 were petrochemical plants, 4 were repair and rehabilitation power production plants, one was manufacturing plant, and one was repair and rehabilitation chemical plant project. The interview sites were spread demographically covering four states including Texas, Tennessee, Alabama, and Louisiana. The below section would provide a comparison of the responses received when frontline supervisors were interviewed and asked the same questions across the 9 sites interviewed. For questions pertaining to constraint management, external production impediments faced, training opportunities available, and work packaging, responses received clearly denote a difference between the two production environments. These observations are in line with the previous research studies that support the fact that productivity enhancement practices including AWP act as a buffer and shield the production from external forces that might negatively impact the production. It is important to note here that the evidences provided in the below section highlight the areas which demonstrate qualitative differences between traditional and AWP environments.

Planning impediments to production- engineering deliverables: When questions related to external impediments to production including problems with engineering deliverables were asked to the respondents in the two construction environments; the responses received are elaborated in Table 35 below. A comparison of the responses given by an Ironworker and Electrical General Foreman in AWP and traditional work environments on similar scope projects, explains that in AWP construction environments, accurate engineering deliverables including complete work packages, enable frontline supervisors in AWP environments to reduce their cognitive load, whereas the frontline supervisors in traditional environments experience high cognitive load in making decisions and searching for information which is readily available in work packages in an AWP work environment.

Table 35 Planning impediments to production- engineering deliverables- Interview Responses

AWP		Traditional	
Respondent	Quote	Respondent	Quote
Project: AWP site, petrochemical expansion, Louisiana		Project: Traditional site, petrochemical expansion, Texas	
GF, Ironworker	"I have a planner to keep my stuff straight. The site is facing no engineering issues and on an average, I spend 8/10 hours in the field. Everything is very organized, less rework, injuries, and more productive work."	GF, Electrical	"I use my common sense to plan work according to the schedule. Cable sizes change a lot and must be changed last minute. Coordination between trades is not thorough, they get to know job status only during walkthroughs. This project has serious issues with errors in drawings that have to be sent back for revision, causing delays."

Completeness of Work Packages: When questions related to completeness of work packages were asked to the respondents in the two construction environments; the responses received are elaborated in Table 36 below. A comparison of the responses given by a Workface Planner and Ironworker Foreman in AWP and traditional work environments on similar scope projects, explains that in AWP construction environments, work packages are clear and complete and evidence support that after the successful implementation of AWP, the project was completed in half the time taken by the similar scope traditional project. Concerns regarding the quality of materials, due to inaccurate

drawings was also brought forward to further reinforce the findings of this research chapter. Similarly, when responses from two other projects, including a petrochemical plant in Louisiana and a manufacturing plant in Texas, were compared, an Ironworker General Foreman in AWP environment elaborated on the ease of availability of information in work packages. However, a Laborer Foreman explained how work packages were incomplete and the quality of engineering deliverables was not adequate.

Table 36 Completeness of Work Packages- Interview Responses

Case 1			
AWP		Maintenance	
Respondent	Quote	Respondent	Quote
Project: Workface planning site, petrochemical expansion, Texas		Project: Coal power plants, Alabama	
Planner, Pipe	"Work packages contain Isometrics with weld mapping, model shots, rod slips, chapterwork, support details, equipment drawings, vessel drawings, and tower drawings. High level of planning has increased productivity figures, for example in fractionating tower, without AWP it took 2 years, whereas with AWP, only 1 year"	Foreman, Ironworker	"Parts are fabricated wrong a lot of times. They are not measured as per site conditions. They tend to interfere with the valves."
Case 2			
AWP		Traditional	
Respondent	Quote	Respondent	Quote
Project: AWP site, petrochemical expansion, Louisiana		Project: Manufacturing plant, Texas	
GF, Ironworker	"Work packages contain model shots, itemized materials, cut sheets, literally everything"	F, Laborer	"Work packages are not complete, they are terrible. A whole lot of information is missing. It is not very well linked up with other trades."

CONCLUSIONS

The quantitative analysis of surveys including a comparison of time allocation of frontline supervisors with and without AWP training in both traditional and AWP environments and comparison of time allocation in traditional and AWP environments establishes frontline supervisors in AWP environments spend their time more effectively and in the proposed ideal ranges by the researchers. By qualitative analysis of case study interviews executed by the researchers in the two environments, the researchers establish that AWP environments facilitate the frontline supervisors to perform better by providing complete work packages, engineering deliverables, and active constraint management. AWP ensures efficient pre-planning from the beginning of the project to turnover of the facility. Also, the philosophy behind AWP to provide right things to the right people at the right time ensures that frontline supervisors spend maximum time in supervising and motivating their crew and ensuring production.

The research team proposes to the industry to make a unified investment to adopt productivity enhancing practices to ensure that the construction productivity increases. AWP provides more predictability to the dynamic construction projects and aims to reduce non-productive time. The participating members of Research team and interviewees on the AWP sites recommend AWP practices on industrial construction projects. The improved predictability and productivity on industrial construction projects is imperative.

Chapter 5: Construction Foremen and General Foremen Perceptions of Impediments to their Productivity

The perception of craft workers of the factors affecting their construction productivity has been quantified in a CII sponsored research project RT 215 titled "Work Force View of Construction Productivity" which quantified the relative impact of eighty-three productivity factors and involved nearly two thousand craft workers out of which nearly twenty-six percent were Foremen and General Foremen (Construction Industry Institute 2006). This research was conducted in 2006 and it presented the top ten most significant factors which influenced the productivity of construction craft workers. It was deduced that seven of the top ten factors involved equipment, tools and consumables, and materials. The remaining two factors involved engineering drawing management including errors and incomplete engineering information.

CII RT 215 published the results on workforce view of construction productivity. The results are based on both Frequency and intensity scales defined. Based on the results published by the research mentioned above and Delphi Method involving expert opinion of construction professionals in the CII Research team RT 330 titled "Improving Frontline Supervision in Industrial Construction" identified five field impediments and six planning impediments to construction productivity. Along with identifying the impediments, this research surveyed foremen and general foremen and presented an average of their responses on a 5-point Likert scale. It also compared the average scores across different productivity regimes including traditional and AWP projects for both Foremen and General Foremen. The purpose of this analysis was to compare the results with the results of the

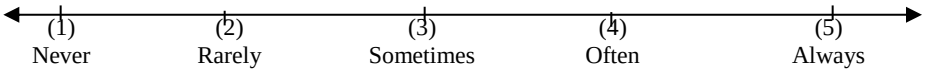
research team in 2006 and compare differences if any. Research team RT 330 observed that the productivity impediments defined in RT 215 remain the top impediments today faced by the frontline supervisors.

The sections below would firstly list the field and planning impediments identified by the team. Secondly, they would elaborate on the five-point Likert scale and the associated ratings. A further analysis is presented which would compare the averages across the different productivity regimes for both Foremen and General Foremen. T-tests are also performed on the data sample to compare the averages in two different groups and establish statistical significance in the difference of means of the two samples being compared namely traditional and AWP environments. The previous chapters of the thesis have established the research hypothesis with regards to the difference in AWP and traditional environments.

Table 37 Field and Planning/Workforce Impediments to Construction Productivity

Part A: Field Impediments to Construction Productivity
1. Waiting for Material
2. Waiting for Equipment (for example crane, forklift, etc.)
3. Problems with power tools (availability, reliability, power sources, etc.)
4. Quality problems in case of prefabricated items
5. Scaffolding issues
Part B: Planning/Workforce Impediments to Construction Productivity
1. Errors in Engineering Drawings/ Inadequate Engineering Support
2. Lack of effective Pre-Planning
3. Current skill level of the workforce
4. Field changes/ Rework
5. Manpower Turnover
6. Work disruptions

Along with identifying the impediments, this research asked Foremen and General Foremen on industrial construction sites in the United States and Canada to rate the impediments on their respective construction sites on a scale of 1 to 5. The Likert scale is presented below:



With 1 being that the impediment is never faced, and 5 being that the impediment occurs very frequently on their construction job site. The scale is by the frequency of occurrence of the respective construction productivity Impediments. The average results for each of the above categories for a total of 1140 respondents including 812 Foremen and 328 General Foremen have been presented in this section. The mean scores are presented in Table 38.

Table 38 General Foremen and Foremen Average scores- Impediments

Part A: Field Impediments	**GF Avg.**	**F Avg.**
Waiting for Material	3.16	3.11
Waiting for Equipment	2.82	2.97
Problems with power tools	2.31	2.30
Quality problems in case of prefabricated items	2.49	2.43
Scaffolding issues	2.57	2.59
Part B: Planning/Workforce Impediments	**GF Avg.**	**F Avg.**
Errors in Engineering Drawings	2.75	2.61
Lack of effective Pre-Planning	2.72	2.63
Current skill level of the workforce	2.91	2.84
Field changes/ Rework	2.94	2.89
Manpower Turnover	2.58	2.57
Work disruptions	2.76	2.74

For Field impediments, the average rating for General Foremen varied between 2.31 (between rarely and sometimes) for “Problems with power tools” and 3.16 (between sometimes and often) for “Waiting for Material”. For Foremen, the average rating varied between 2.30 (between rarely and sometimes) for “Power Tools” and 3.11 (between sometimes and often) for “Waiting for Material”. Hence, it is observed that both the Foremen and General Foremen, the least and most occurring impediments to productivity remain the same being associated with power tools and material respectively. Generally, the average rating for each of the field impediments for Foremen is less than that for General Foremen apart from that in “Waiting for Equipment” and “Scaffolding issues”. However, the reasoning behind the averages cannot be explained.

For Planning/Workforce Impediments, the average rating for General Foremen varied between 2.58 (between rarely and sometimes) for “Manpower Turnover” and 2.94 (between rarely and sometimes) for “Field Changes/Rework”. For Foremen, the average rating varied between 2.57 (between rarely and sometimes) for “Manpower Turnover” and 2.89 (between rarely and sometimes) for “Field Changes/Rework”. Hence, it is observed that both the Foremen and General Foremen, the least and most occurring impediments to productivity remain the same being associated with “Manpower turnover” and “Field changes/rework” respectively. For each of the planning/workforce impediments, the average rating for Foremen is less than that for General Foremen. However, the reasoning behind the averages cannot be explained.

After comparing the average of responses for Field and Planning Impediments for both Foremen and General Foremen for all projects and all responses together. The

research team compared the means of the two samples including traditional and AWP projects for each of the 5 Field Impediments and 6 Planning/Workforce Impediments. After separating responses in two different sample sets including traditional and AWP environments, t-tests were performed on each of the categories listed above separately to establish the difference in means. The results of the t-test including p-values have been provided in Table 39 and Table 40.

Table 39 General Foremen Productivity Impediments, Traditional vs. AWP

General Foremen			
Part A: Field Impediments	**Traditional**	**AWP**	**p-value**
Waiting for Material	3.35	3.19	0.203
Waiting for Equipment	2.94	2.96	0.441
Problems with power tools	2.44	2.20	0.045
Quality problems in case of prefabricated items	2.46	2.98	0.003
Scaffolding issues	2.51	3.15	0.0006
Part B: Planning/Workforce Impediments	**Traditional**	**AWP**	**p-value**
Errors in Engineering Drawings	2.86	2.36	0.002
Lack of effective Pre-Planning	2.84	2.56	0.062
Current skill level of the workforce	2.92	2.75	0.165
Field changes/ Rework	2.98	2.89	0.262
Manpower Turnover	2.72	2.45	0.042
Work disruptions	2.88	2.52	0.009

For General Foremen Field impediments based on the frequency of occurrence on their respective job sites, in accordance with the Hypothesis; 2 out of 5 impediments including Waiting for material and power tools the General Foremen in AWP environment rate frequency of impediments lesser than those in traditional environments. According to the research hypothesis, in AWP work environments, due to effective pre-planning and shielding of the work environment from external impediments, it is observed that these working environments face lesser productivity impediments in comparison to the traditional environments. Further, it is observed that the result is not statistically significant for a p-value of 0.20 for the category of "Waiting for Material". It is statistically significant for a p-value of 0.045 in the category of "Problem with Power Tools". T-tests are performed assuming one side hypothesis that the mean of responses for traditional environments would be more than the mean of responses for AWP environments. Assuming this hypothesis, and corresponding to the t-value, the software is used to calculate the p-value. The accepted p-value in social sciences research is 0.10.

For Planning/Workforce impediments, for all the categories, the respondents in traditional work environments have marked the impediments on a higher scale in comparison to the respondents in the AWP environments. The result of the difference in means holds statistical significance with a p-value of less than 0.10 for 4 out of 6 categories.

Table 40 Foremen Productivity Impediments, Traditional vs. AWP

Foremen			
Part A: Field Impediments	**Traditional**	**AWP**	**p-value**
Waiting for Material	3.35	3.16	0.029
Waiting for Equipment	3.23	2.83	1.81E-05
Problems with power tools	2.41	2.20	0.009
Quality problems in case of prefabricated items	2.46	2.69	0.009
Scaffolding issues	2.44	3.06	2.77E-08
Part B: Planning/Workforce Impediments	**Traditional**	**AWP**	**p-value**
Errors in Engineering Drawings	2.70	2.38	0.0001
Lack of effective Pre-Planning	2.79	2.47	0.0004
Current skill level of the workforce	2.90	2.72	0.032
Field changes/ Rework	3.00	2.82	0.025
Manpower Turnover	2.68	2.42	0.001
Work disruptions	2.78	2.57	0.004

For Foremen Field impediments based on the frequency of occurrence on their respective job sites, in accordance with the Hypothesis; 3 out of 5 impediments including Waiting for material, power tools, and waiting for equipment the Foremen in AWP environment rate frequency of impediments lesser than those in traditional environments.

Further, it is observed that the result is statistically significant for all the three above stated impediments to productivity.

For Planning/Workforce impediments, for all the categories, the respondents in traditional work environments have marked the impediments on a higher scale in comparison to the respondents in the AWP environments. The result of the difference in means holds statistical significance with a p-value of less than 0.10 for all the six categories.

These results support the hypothesis, as presented by the research that for AWP environments, the impediments are lessened due to the effective pre-planning and buffers to production. This is said, keeping in mind that the rating may also be a function of the organizational structure and other external factors that might not have been covered in the survey. The research team also suggests further investigation with more demographically spread projects and different production environments within the heavy and light industrial projects. The results are also in line with the productivity impediments as highlighted during another CII sponsored research on “RT 215: Work Force view of Construction Productivity”.

Chapter 6: Conclusions

The several hundred surveys and interviews conducted by RT 330 have validated the hypotheses that, in general, the Foremen and General Foremen working on today's industrial construction sites exhibit room for improvement in the competencies needed to lead and manage their workforce effectively. Also, frontline supervisors in industrial construction projects are spending considerable time on tasks apart from what the Research Team RT330, considers ideal or target ranges. Further, the results also exhibit that frontline supervisors in AWP environments spend their time more effectively in comparison to their counterparts in traditional work environments. Also, AWP training is observed to have a positive impact on frontline supervisors in both traditional and AWP execution environments. The Research team has also suggested by statistical analysis that the impediments faced by frontline supervisors in AWP environments are lesser in scale when compared to their counterparts in traditional settings. Having deduced this, by analysis of surveys and interviews, the researchers also acknowledge that the results might be due to the internal characteristics and organizational structures of the projects considered. Hence the research team further suggests more research demographically and across different production environments within the industrial sector.

Principal conclusions of the research are that:

1. Foremen and General Foremen have ten core competencies that are uniformly seen as important to their performance. These fundamental competencies are the same across all project types (traditional, maintenance, and Advanced Work Packaging).

2. Survey and interview data support the hypothesis that both Foremen and General Foremen competency levels in the industry are below desirable levels. This is particularly true for Foremen. Investment to improve these competencies may be one of the biggest opportunities the industry has to improve construction productivity and performance.

3. On all project types, survey results show that Foremen and General Foremen spend a considerable amount of time away from what the research team designated as ideal or target time budgeted for their primary tasks. While some variation is to be expected, better allocation of frontline supervisor time could yield significant productivity improvements.

4. There is evidence that Advanced Work Packaging improves frontline supervision time on task compared to traditional projects. Time differences are significant in aggregate. Interview results demonstrate AWP project frontline supervisors provide more uniformly focused answers about their tasks than do traditional project frontline supervisors.

5. AWP training is generally seen as beneficial to Foremen and General Foremen on both traditional and AWP projects.

6. 5 Field and 6 Planning impediments are identified in this thesis. For General Foremen, 2 out of 5 field impediments and all 6 planning impediments, the respondents in traditional execution environments face impediments on a higher scale than their counterparts in AWP projects. Similarly for Foremen, 3 out of 5 field impediments and all 6 planning impediments, the respondents in traditional execution environments face

impediments on a higher scale than their counterparts in AWP projects. These results support the hypothesis, as presented by the research that for AWP environments, the impediments are lessened due to the effective pre-planning and buffers to production.

Concluding Observations

Frontline supervisors are the managers who have the most influence on day-to-day work that determines field productivity. As an industry, we have underinvested in education and in associated screening, retention, and promotion of Foremen and General Foremen. This is seen in poor assessment of their competencies and in the varied way they allocate their time. Even small changes in how Foremen and General Foremen spend their day can, in aggregate, make significant improvements to productivity of crews. While the findings for the industry show significant problems, this also means there is a direct opportunity to improve. As an industry, we have many challenges to improve the skills and competencies of the field workforce. Not all of these are easily addressable. However, investing in Foremen and General Foremen is a tangible action the industry can take to improve that will show benefits.

Appendices

APPENDIX A- SUPERINTENDENTS AND CRAFT MANAGERS SURVEY

The purpose of this survey is to gather data about Foremen and General Foremen skills and competencies. This is part of Construction Industry Institute (CII) sponsored research regarding the role of frontline supervision in enhancing productivity. Your assistance will help to understand the skills and competencies of Foremen and General Foremen across the industry and will help focus efforts for improvement. You have been selected to participate in this survey. Your responses in the survey will be kept highly confidential.

SECTION 1: TRADE FOREMAN/GENERAL FOREMAN SKILL/COMPETENCY COMPARISON

Please consider and give responses only for the trades of which you are knowledgeable.

Do you believe Foremen/General Foreman skills vary across trades or disciplines?
□ Yes □No

For each trade Foreman/General Foreman below, please provide your feedback on whether each trade is stronger, average, or weaker as compared to all other trades. (Place an "X" in the appropriate column for each trade)

Table A.1 Table comparing skills among different trades

Trade Foreman/ General Foreman	Stronger	Average	Weaker	Don't know/ unsure
Civil/ Labor				
Millwrights				
Iron Workers				
Pipefitters				
Pipefitter Welders				
Boilermakers				
Electricians/ Instrumentation workers				
Insulation workers				
Carpenters				
Sheet Metal Workers				
Painters				

SECTION 2: TRADE FOREMAN/GENERAL FOREMAN SKILL IMPORTANCE TO PERFORMANCE:

Based on your recent experience, assess the importance of the following skills to productivity performance for Foremen/General Foremen. Select the appropriate number below for each category using the following scale:

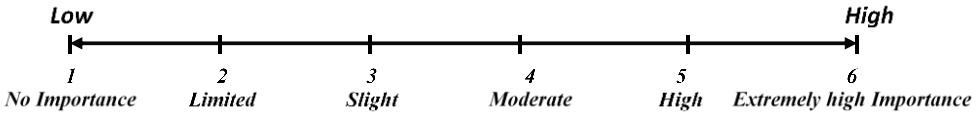


Table A.2 Table comparing responses to importance to Performance

Skill	FOREMEN						GENERAL FOREMEN					
	Importance to Performance						Importance to Performance					
	Low					High	Low					High
General Construction Knowledge	1	2	3	4	5	6	1	2	3	4	5	6
Trade Specific Knowledge	1	2	3	4	5	6	1	2	3	4	5	6
Verbal Communication	1	2	3	4	5	6	1	2	3	4	5	6
Written Communication	1	2	3	4	5	6	1	2	3	4	5	6
Pre Planning	1	2	3	4	5	6	1	2	3	4	5	6
Problem Solving	1	2	3	4	5	6	1	2	3	4	5	6
Ethical (Trustworthy, fair, empathetic, and even handed)	1	2	3	4	5	6	1	2	3	4	5	6
People Management (Task assignments, delegating, conflict resolution, discipline)	1	2	3	4	5	6	1	2	3	4	5	6
Leadership	1	2	3	4	5	6	1	2	3	4	5	6
Proactive and Goal Driven	1	2	3	4	5	6	1	2	3	4	5	6

SECTION 3: TRADE GENERAL FOREMAN SKILL ASSESSMENT:

Based on your recent experience, assess the skills for General Foremen. Select the appropriate number below for each category using the following scale:

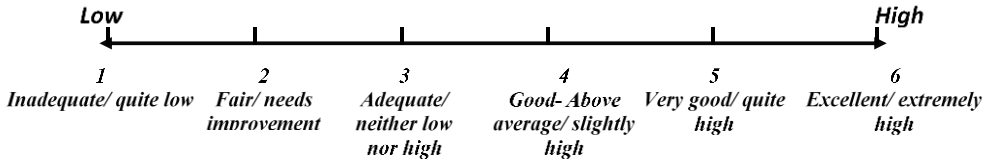


Table A.3 Table for observed skill level

Skill	FOREMEN						GENERAL FOREMEN					
	Observed skill level						Observed skill level					
	Low					High	Low					High
General Construction Knowledge	1	2	3	4	5	6	1	2	3	4	5	6
Trade Specific Knowledge	1	2	3	4	5	6	1	2	3	4	5	6
Verbal Communication	1	2	3	4	5	6	1	2	3	4	5	6
Written Communication	1	2	3	4	5	6	1	2	3	4	5	6
Pre Planning	1	2	3	4	5	6	1	2	3	4	5	6
Problem Solving	1	2	3	4	5	6	1	2	3	4	5	6
Ethical (Trustworthy, fair, empathetic, and even handed)	1	2	3	4	5	6	1	2	3	4	5	6
People Management (Task assignments, delegating, conflict resolution, discipline)	1	2	3	4	5	6	1	2	3	4	5	6
Leadership	1	2	3	4	5	6	1	2	3	4	5	6
Proactive and Goal Driven	1	2	3	4	5	6	1	2	3	4	5	6

SECTION 4: GENERAL INFORMATION:

- What is your role in the organization?

□ Site Manager □Construction Manager □General Superintendent □Craft Superintendent
□ Project Manager □ Project Director □Other

If you selected other, specify _____

- Please indicate your years of construction experience:

□ 0-5 □ 5-10 □ 10-15 □ 15-20 □ 20-25 □ >25

- Primary Geographic Region of work:

□Northwest (WA, OR, ID) □Southwest (CA, NV, AZ) □Mountain (MT, WY, ID, UT, CO, SD, ND) □Central (NE, IA, KS, MO, NM, OK, AR, LA, TX) □Midwest (MN, WI, IL, OH, MI, IN) □Northeast (PA, WV, VA, NY, VT, NH, MA, RI, CT) □Southeast (KY, TN, NC, SC, MS, AL, GA, FL) □Canada (West) □Canada (East)

- Please indicate your type of work

□ Heavy Industrial □ Light Industrial

- Please indicate the primary labour contract type you work under:

□ Lump Sum □ Unit Rate □ Reimbursable

- What is the average number of craft/workforce on projects that you manage?

□ 0-50 □ 51-150 □ 151-300 □ 301-500 □ 501-1000 □ >1000

- Primary form of labour agreement you work under:

□ Union □ Open Shop □ Other Labor Agreements

- Does your work typically utilize: (Check all that apply)

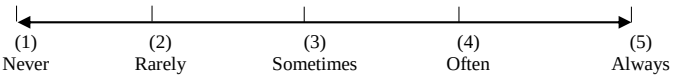
□ Advanced Work Packaging (AWP) □Work Face Planning (WFP) □ Lean Construction □ Six Sigma

- What is the total project cost of your current project in millions?

□ 0-15 □ 16-50 □ >51

SECTION 5: PRODUCTTIVITY IMPEDIMENTS AND SUGGESTIONS:

The next two questions ask you to rate productivity impediments on basis of frequency on a scale of 1 to 5. Select the appropriate number below for each category using the following scale.



- Rate the following impediments on basis of frequency in terms of effect on productivity.

Field Impediments	Frequency Low				High
Waiting for material	1	2	3	4	5
Waiting for equipment (for example crane, forklift, etc.)	1	2	3	4	5
Problems with power tools (availability, reliability, power	1	2	3	4	5
Quality problems in case of prefabricated items	1	2	3	4	5
Scaffolding issues	1	2	3	4	5

- Rate the following impediments on basis of frequency in terms of effect on productivity.

Planning/ Workforce Impediments	Frequency Low				High
Errors in engineering drawings/ Inadequate engineering support	1	2	3	4	5
Lack of effective preplanning	1	2	3	4	5
Current skill level of the workforce	1	2	3	4	5
Field changes / rework	1	2	3	4	5
Manpower turnover	1	2	3	4	5
Work disruptions	1	2	3	4	5

- Please state other impediments if they are not in the above lists: _____ _____ _____ _____

- What suggestions do you have to increase productivity? _____ _____ _____ _____

APPENDIX B- FOREMEN SURVEY

Foreman Survey

This survey is part of Construction Industry Institute (CII) sponsored research regarding the role of frontline supervision in enhancing productivity. Your response to the following questions will help us better understand the amount of time you spend each day performing certain tasks and items that may limit field productivity. Your responses will be forwarded to researchers at the University of Texas at Austin and kept confidential.

SECTION 1: FOREMAN/ALLOCATION OF TIME

Based on your current work day, please circle the number of minutes/hours that you spend each shift performing the indicated tasks.

Task	Minutes/Hours Per Day Spent (Circle Only One)		
1. Meetings – Client/Coordination/Scheduling/Look Ahead	15 -60 mins.	1.5 -2 hrs.	2 -4 hrs.
2. Plan/Prioritize Tasks & Fallback Work (Plan "B")	0-30 mins.	45-90 mins.	2-3 hrs.
3. Safety Related Activities – Meetings/JHA Development/Inspections/Action Items/Sign/Review FLHAs	0 -15 mins.	30 -60 mins.	1.5 -3 hrs.
4. Complete Paperwork	10 -25 mins.	30 -60 mins.	65 -90 mins.
5. Coordinate with other Crews/Support	0 mins.	5 -15 mins.	16 -25 mins.
6. Supervise/Motivate/Execute	4 hrs. or less	5 -6 hrs.	8 hrs. or more
7. Plan for Future Work	15 -35 mins.	45 -1.25 hrs.	1.5 -2 hrs.
8. Work on Tools with Crew	0 -15 mins.	15-45 mins.	1-2 hrs.
9. Receive/Check/Verify Materials in Area	0 mins.	5 -15 mins.	16 -25 mins.
10. Move Crews to Contingency Work	0 mins.	5 -15 mins.	16 -25 mins.

SECTION 2: GENERAL INFORMATION

- Circle your Craft:

Civil/Labor	Iron Workers	Mechanical/ Millwright	Pipefitter	Pipefitter Welders
Electrical/ Instruments	Insulation	Carpenter/Scaffolder	Boilermaker	Sheet Metal Worker
Paint	Other:_____			

- Circle your current phase of Job:

Mobilization/ Pre-Construction	Construction/ Bulk Construction	Start-Up & Commissioning

- Circle your Shift:

8 Hour	10 Hour	12 Hour

- Circle your years of construction experience:

1-5	6-10	11-15	16-20	21 or more

- Circle your years of supervisory experience:

1-5	6-10	11-15	16-20	21 or more

- Circle the appropriate current Geographic Region of work:

Northwest (WA, OR, ID)	Southwest (CA, NV, AZ)	Mountain (MT, WY, ID, UT, CO, SD, ND)	Central (NE, IA, KS, MO, NM, OK, AR, LA, TX)	Midwest (MN, WI, IL, OH, MI, IN)	Northeast (PA, WV, VA, NY, VT, NH, MA, RI, CT)	Southeast (KY, TN, NC, SC, MS, AL, GA, FL)	Canada (West)	Canada (East)

- Circle your type of work:

Heavy Industrial	Light Industrial

- Circle the 'typical' crew size you are supervising?

1-5	6-10	11-15	16-20	21+

- Are you a union member? □Yes □No
- Are you currently working on a union project? □Yes □No
- What is the total project cost of your current project cost in millions?

0-15	16-50	>51

- Does your work currently utilize: (Check all that apply)?

□Advanced Work Packaging (AWP)	□Work Face Planning (WFP)	□Lean Construction	□Six Sigma

- Circle your current phase of Job:

Mobilization/ Pre-Construction	Construction/ Bulk Construction	Start-Up & Commissioning

- Circle your Shift:

8 Hour	10 Hour	12 Hour

- Circle your years of construction experience:

1-5	6-10	11-15	16-20	21 or more

- Circle your years of supervisory experience:

1-5	6-10	11-15	16-20	21 or more

- Circle the appropriate current Geographic Region of work:

Northwest (WA, OR, ID)	Southwest (CA, NV, AZ)	Mountain (MT, WY, ID, UT, CO, SD, ND)	Central (NE, IA, KS, MO, NM, OK, AR, LA, TX)	Midwest (MN, WI, IL, OH, MI, IN)	Northeast (PA, WV, VA, NY, VT, NH, MA, RI, CT)	Southeast (KY, TN, NC, SC, MS, AL, GA, FL)	Canada (West)	Canada (East)

- Circle your type of work:

Heavy Industrial	Light Industrial

- Circle the 'typical' crew size you are supervising?

1-5	6-10	11-15	16-20	21+

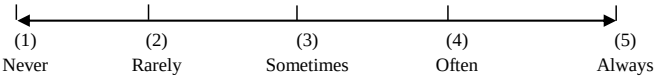
- Are you a union member? □Yes □No
- Are you currently working on a union project? □Yes □No
- What is the total project cost of your current project cost in millions?

0-15	16-50	>51

- Does your work currently utilize: (Check all that apply)?

□Advanced Work Packaging (AWP)	□Work Face Planning (WFP)	□Lean Construction	□Six Sigma

The next two questions ask you to rate productivity impediments on basis of frequency on a scale of 1 to 5. Select the appropriate number below for each category using the following scale.



➢ Rate the following impediments on basis of frequency in terms of effect on productivity.

Field Impediments	Frequency Low				High
Waiting for material	1	2	3	4	5
Waiting for equipment (for example crane, forklift, etc.)	1	2	3	4	5
Problems with power tools (availability, reliability, power sources, etc.)	1	2	3	4	5
Quality problems in case of prefabricated items	1	2	3	4	5
Scaffolding issues	1	2	3	4	5

➢ Rate the following impediments on basis of frequency in terms of effect on productivity.

Planning/ Workforce Impediments	Frequency Low				High
Errors in engineering drawings/ Inadequate engineering support	1	2	3	4	5
Lack of effective preplanning	1	2	3	4	5
Current skill level of the workforce	1	2	3	4	5
Field changes / rework	1	2	3	4	5
Manpower turnover	1	2	3	4	5
Work disruptions	1	2	3	4	5

➢ Please state other impediments if they are not in the above lists:

_____

_____

➢ What suggestions do you have to increase productivity?

_____

_____

➢ Have you had training in any of the following areas (check all that apply):

- Safety
- Estimating
- Effective Communication
- Lean Construction
- Quality Control
- Supervisory Skills
- AWP/WFP
- Time Motion Studies
- Scheduling
- 3D/BIM Model
- Time Management

Is there any specific training you would like to receive that would increase your productivity?

_____

_____

➢ Do you have clerical or administrative support? □Yes □No

Do you have access to a computer? □Yes □No

APPENDIX C- GENERAL FOREMEN SURVEY

General Foreman Survey

This survey is part of Construction Industry Institute (CII) sponsored research regarding the role of frontline supervision in enhancing productivity. Your response to the following questions will help us better understand the amount of time you spend each day performing certain tasks and items that may limit field productivity. Your responses will be forwarded to researchers at the University of Texas at Austin and kept confidential.

SECTION 1: GENERAL FOREMAN/ALLOCATION OF TIME

Based on your current work day, please circle the number of minutes/hours that you spend each shift performing the indicated tasks.

Task	Minutes/Hours Per Day Spent (Circle Only One)		
1. Meetings – Client/Coordination/Scheduling/Look Ahead	15 -60 mins.	1.5 -2 hrs.	2 -4 hrs.
2. Plan/Prioritize Tasks & Fallback Work (Plan "B") with Foremen	0 -30 mins.	45 -90 mins.	2 -3 hrs.
3. Safety Related Activities – Meetings/JHA Development/Inspections/Action Items/Sign/Review FLHAs	0 -15 mins.	30 -60 mins.	1.5 -3 hrs.
4. Constraint Mgt. – Ensure FM has all Crane support/crane/scaffold/Material/Equipment	0 -30 mins.	60 -90 mins.	2 -3 hrs.
5. Follow up with FM & Crews Throughout Day – Work Area Reviews/Productivity Check in Field	30 -45 mins.	1.5 -3 hrs.	4 -6 hrs.
6. Work Package Development – Model Review/FIWP Review/FIWP Schedule/Close-Out FIWPs	0 -30 mins.	1 -2 hrs.	3 -4 hrs.
7. Communicate with Field Engineers – Develop Estimates for Extra Work/RFIs	0 -15 mins.	30 -60 mins.	1.5 -3 hrs.
8. Complete Progress/Timesheets/Forecasts/Review Installed Quantities/Cost Codes	0 -15 mins.	30 -60 mins.	1.5 -3 hrs.

SECTION 2: GENERAL INFORMATION

- Circle your Craft:

Civil/Labor	Iron Workers	Mechanical/ Millwright	Pipefitter	Pipefitter Welders
Electrical/ Instruments	Insulation	Carpenter/Scaffolder	Boilermaker	Sheet Metal Worker
Paint	Other:_____			

- Circle your current phase of Job:

Mobilization/ Pre-Construction	Construction/ Bulk Construction	Start-Up & Commissioning

- Circle your Shift:

8 Hour	10 Hour	12 Hour

- Circle your years of construction experience:

1-5	6-10	11-15	16-20	21 or more

- Circle your years of supervisory experience:

1-5	6-10	11-15	16-20	21 or more

- Circle the appropriate current Geographic Region of work:

Northwest (WA, OR, ID)	Southwest (CA, NV, AZ)	Mountain (MT, WY, ID, UT, CO, SD, ND)	Central (NE, IA, KS, MO, NM, OK, AR, LA, TX)	Midwest (MN, WI, IL, OH, MI, IN)	Northeast (PA, WV, VA, NY, VT, NH, MA, RI, CT)	Southeast (KY, TN, NC, SC, MS, AL, GA, FL)	Canada (West)	Canada (East)

- Circle your type of work:

Heavy Industrial	Light Industrial

- Circle the 'typical' number of Foreman you are supervising?

1-2	3-4	5-6	7-8	8-10

- Are you a union member? □Yes □No
- Are you currently working on a union project? □Yes □No
- What is the total project cost of your current project in millions?

0-15	16-50	>51

- Does your work currently utilize? (Check all that apply)

□Advanced Work Packaging (AWP)	□Work Face Planning (WFP)	□Lean Construction	□Six Sigma

The next two questions ask you to rate productivity impediments on basis of frequency on a scale of 1 to 5. Select the appropriate number below for each category using the following scale.

- Rate the following impediments on basis of frequency in terms of effect on productivity.

Field Impediments	Frequency				
	Low				High
Waiting for material	1	2	3	4	5
Waiting for equipment (for example crane, forklift, etc.)	1	2	3	4	5
Problems with power tools (availability, reliability, power sources, etc.)	1	2	3	4	5
Quality problems in case of prefabricated items	1	2	3	4	5
Scaffolding issues	1	2	3	4	5

- Rate the following impediments on basis of frequency in terms of effect on productivity.

Planning/ Workforce Impediments	Frequency				
	Low				High
Errors in engineering drawings/ Inadequate engineering support	1	2	3	4	5
Lack of effective preplanning	1	2	3	4	5
Current skill level of the workforce	1	2	3	4	5
Field changes / rework	1	2	3	4	5
Manpower turnover	1	2	3	4	5
Work disruptions	1	2	3	4	5

- Please state other impediments if they are not in the above lists:

_____

_____

- What suggestions do you have to increase productivity?

_____

_____

- Have you had training in any of the following areas (check all that apply):

- Safety
- Estimating
- Effective Communication
- Lean Construction
- Quality Control
- Supervisory Skills
- AWP/WFP
- Time Motion Studies
- Scheduling
- 3D/BIM Model
- Time Management

Is there any specific training you would like to receive that would increase your productivity?

_____

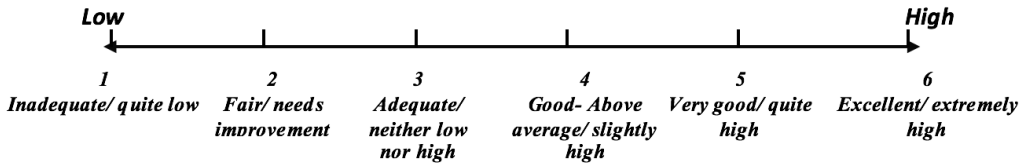
_____

- Do you have clerical or administrative support? □Yes □No

Do you have access to a computer? □Yes □No

SECTION 3: TRADE FOREMAN SKILL ASSESSMENT:

Based on your recent experience, assess the average skills of **foremen** in each of the following categories. This rating will be used to help focus recommendations for education and skills improvement. Select the appropriate number below for each category using the following scale:



Skill	Observed skill level Low					High
General Construction Knowledge	1	2	3	4	5	6
Trade Specific Knowledge	1	2	3	4	5	6
Verbal Communication	1	2	3	4	5	6
Written Communication	1	2	3	4	5	6
Pre Planning	1	2	3	4	5	6
Problem Solving	1	2	3	4	5	6
Ethical (Trustworthy, fair, empathetic, and even handed)	1	2	3	4	5	6
People Management (Task assignments, delegating, conflict resolution, discipline)	1	2	3	4	5	6
Leadership	1	2	3	4	5	6
Proactive and Goal Driven	1	2	3	4	5	6

APPENDIX D- SUPERINTENDENT SURVEY- DATA

Q1.2 - Please indicate your current role in the organization. Responses include; 1.Foreman 2.General Foreman 3.Superintendents and Managers with craft knowledge. Please select Option 3 if your role includes but is not limited to the following: Site Manager, Construction Manager, General Superintendent, Craft Superintendent, Project Manager, Project Director or equivalent positions

	Answer	%	Count
1	3. Superintendents and managers with craft knowledge	100.00%	86
	Total	100%	86

Q2.2 - Do you believe Foremen/General Foreman skills vary across trades or disciplines?

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	Do you believe Foremen/General Foreman skills vary across trades or disciplines?	1.00	2.00	1.06	0.23	0.05	86

Q2.3 - For each trade Foreman/General Foreman below, please provide your feedback on whether each trade is stronger, average, or weaker as compared to all other trades. Please consider and give responses only for trades of which you are knowledgeable.

#	Question	Stronger		Average		Weaker		Unsure		Total
1	Civil/Labor	14.5%	9	58.1%	36	22.6%	14	4.8%	3	62
2	Millwrights	36.8%	21	42.1%	24	14.0%	8	7.0%	4	57
3	Iron Workers	24.6%	16	56.9%	37	15.4%	10	3.1%	2	65
4	Pipefitters	20.3%	13	43.8%	28	32.8%	21	3.1%	2	64
5	Pipe fitters/welders	17.7%	11	54.8%	34	24.2%	15	3.2%	2	62
6	Boilermakers	15.8%	9	52.6%	30	22.8%	13	8.8%	5	57
7	Electricians/ Instrumentation workers	54.5%	30	34.5%	19	5.5%	3	5.5%	3	55
8	Insulation workers	9.8%	5	31.4%	16	43.1%	22	15.7%	8	51
9	Carpenters	18.0%	11	59.0%	36	18.0%	11	4.9%	3	61
10	Sheet Metal Workers	4.0%	2	44.0%	22	34.0%	17	18.0%	9	50
11	Painters	3.5%	2	35.1%	20	50.9%	29	10.5%	6	57

Q2.5#1 - FOREMEN

#	Field	Minimum	Maximum	Mean	Std Deviation	Variance	Count
1	General Construction Knowledge	3.00	6.00	4.73	0.77	0.60	75
2	Trade Specific Knowledge	4.00	6.00	5.29	0.69	0.48	73
3	Verbal Communication	3.00	6.00	5.17	0.93	0.86	75
4	Written Communication	2.00	6.00	4.45	0.98	0.97	75
5	Pre Planning	3.00	6.00	5.12	0.89	0.79	76
6	Problem Solving	2.00	6.00	4.87	0.96	0.92	75
7	Ethical (Trustworthy, fair, empathetic, and even handed)	3.00	6.00	5.46	0.78	0.61	72
8	People Management (Task assignments, delegating, conflict resolution, discipline)	3.00	6.00	5.15	0.86	0.75	74
9	Leadership	3.00	6.00	5.28	0.83	0.68	75
10	Proactive and Goal Driven	3.00	6.00	5.24	0.85	0.72	75

Q2.5#2 - GENERAL FOREMEN

#	Question	1		2		3		4		5		6		Total
1	General Construction Knowledge	0.00%	0	0.00%	0	0.00%	0	14.67%	11	38.67%	29	46.67%	35	75
2	Trade Specific Knowledge	0.00%	0	0.00%	0	0.00%	0	8.22%	6	26.03%	19	65.75%	48	73
3	Verbal Communication	0.00%	0	0.00%	0	4.00%	3	9.33%	7	26.67%	20	60.00%	45	75
4	Written Communication	1.33%	1	0.00%	0	8.00%	6	22.67%	17	30.67%	23	37.33%	28	75
5	Pre Planning	1.32%	1	0.00%	0	2.63%	2	6.58%	5	15.79%	12	73.68%	56	76
6	Problem Solving	0.00%	0	1.33%	1	1.33%	1	10.67%	8	32.00%	24	54.67%	41	75
7	Ethical (Trustworthy, fair, empathetic, and even handed)	0.00%	0	0.00%	0	1.39%	1	8.33%	6	20.83%	15	69.44%	50	72
8	People Management (Task assignments, delegating, conflict resolution, discipline)	0.00%	0	0.00%	0	2.70%	2	5.41%	4	28.38%	21	63.51%	47	74
9	Leadership	0.00%	0	0.00%	0	2.67%	2	6.67%	5	21.33%	16	69.33%	52	75
10	Proactive and Goal Driven	0.00%	0	0.00%	0	2.67%	2	6.67%	5	25.33%	19	65.33%	49	75

Q2.7#1 - FOREMEN

#	Question	1		2		3		4		5		6		Total
1	General Construction Knowledge	1.39%	1	5.56%	4	40.28%	29	34.72%	25	16.67%	12	1.39%	1	72
2	Trade Specific Knowledge	0.00%	0	6.85%	5	21.92%	16	36.99%	27	27.40%	20	6.85%	5	73
3	Verbal Communication	1.41%	1	14.08%	10	23.94%	17	36.62%	26	16.90%	12	7.04%	5	71
4	Written Communication	5.56%	4	23.61%	17	25.00%	18	31.94%	23	9.72%	7	4.17%	3	72
5	Pre Planning	1.43%	1	21.43%	15	28.57%	20	25.71%	18	14.29%	10	8.57%	6	70
6	Problem Solving	2.82%	2	14.08%	10	29.58%	21	35.21%	25	14.08%	10	4.23%	3	71
7	Ethical (Trustworthy, fair, empathetic, and even handed)	0.00%	0	4.23%	3	26.76%	19	32.39%	23	22.54%	16	14.08%	10	71
8	People Management (Task assignments, delegating, conflict resolution, discipline)	2.82%	2	11.27%	8	26.76%	19	30.99%	22	22.54%	16	5.63%	4	71
9	Leadership	0.00%	0	12.50%	9	31.94%	23	23.61%	17	22.22%	16	9.72%	7	72
10	Proactive and Goal Driven	1.39%	1	15.28%	11	27.78%	20	23.61%	17	20.83%	15	11.11%	8	72

Q2.7#2 - GENERAL FOREMEN

#	Question	1		2		3		4		5		6		Total
2	Trade Specific Knowledge	1.37%	1	1.37%	1	12.33%	9	30.14%	22	36.99%	27	17.81%	13	73
4	Written Communication	2.78%	2	11.11%	8	23.61%	17	29.17%	21	20.83%	15	12.50%	9	72
6	Problem Solving	0.00%	0	8.33%	6	18.06%	13	33.33%	24	29.17%	21	11.11%	8	72
9	Leadership	0.00%	0	4.17%	3	25.00%	18	22.22%	16	26.39%	19	22.22%	16	72
10	Proactive and Goal Driven	0.00%	0	8.33%	6	20.83%	15	29.17%	21	22.22%	16	19.44%	14	72
1	General Construction Knowledge	0.00%	0	1.41%	1	19.72%	14	39.44%	28	28.17%	20	11.27%	8	71
7	Ethical (Trustworthy, fair, empathetic, and even handed)	0.00%	0	1.41%	1	19.72%	14	28.17%	20	33.80%	24	16.90%	12	71
8	People Management (Task assignments, delegating, conflict resolution, discipline)	0.00%	0	4.23%	3	18.31%	13	36.62%	26	22.54%	16	18.31%	13	71
3	Verbal Communication	0.00%	0	7.14%	5	20.00%	14	32.86%	23	24.29%	17	15.71%	11	70
5	Pre Planning	0.00%	0	7.14%	5	24.29%	17	30.00%	21	18.57%	13	20.00%	14	70

Q2.9 - Please select your role in the organization?

#	Answer	%	Count
1	Site Manager	9.72%	7
2	Construction Manager	6.94%	5
3	General Superintendent	16.67%	12
4	Craft Superintendent	36.11%	26
5	Project Manager	16.67%	12
6	Project Director	1.39%	1
7	Other	12.50%	9
	Total	100%	72

Q2.9_7_TEXT - Other

Other
QA/QC & Welding Manager
Technical Services Manager
Area Manager
wearhouse manager
Division Manager

Q2.10 - Please select the role of your organization in current project.

#	Answer	%	Count
1	Owner	0.00%	0
2	General Contractor/ EPC Contractor	88.73%	63
3	Specialities/ Sub Contractor	11.27%	8
	Total	100%	71

Q2.11 - Please select your years of construction experience

#	Answer	%	Count
1	0-5	0.00%	0
2	5-10	4.17%	3
3	10-15	5.56%	4
4	15-20	16.67%	12
5	20-25	11.11%	8
6	>25	62.50%	45
	Total	100%	72

Q2.12 - Please select the current Geographic region of work

#	Answer	%	Count
1	West (WA, OR, CA, HI, AK)	0.00%	0
2	Southwest (AZ, NM, TX, OK)	73.61%	53
3	Mountain (MT, ID, WY, NV, UT, CO)	0.00%	0
4	Midwest (ND, SD, NE, KS, MN, IA, MS, IL, WI, MI, OH, IN)	12.50%	9
5	Northeast (PA, NY, VT, NH, MA, RI, CT, NJ, ME)	0.00%	0
6	Southeast (KY, TN, NC, SC, MS, AL, GA, FL, WV, DE, MD, AK, LA, VA)	8.33%	6
8	Canada (West)	5.56%	4
9	Canada (East)	0.00%	0
	Total	100%	72

Q2.13 - Please select your type of work

#	Answer	%	Count
1	Heavy Industrial	97.18%	69
2	Light Industrial	2.82%	2
	Total	100%	71

Q2.14 - Please select the primary labor contract type you work under

#	Answer	%	Count
1	Lump Sum	42.25%	30
2	Unit Rate	14.08%	10
3	Reimbursable	36.62%	26
4	Other, Please specify	7.04%	5
	Total	100%	71

Other, Please specify

Other, Please specify
time and material
time and matireal
All the above
salary
salery

Q2.15 - What is the average number of craft/workforce on projects that you manage?

#	Answer	%	Count
1	0-50	19.44%	14
2	51-150	27.78%	20
3	151-300	20.83%	15
4	301-350	9.72%	7
5	501-1000	13.89%	10
6	>1000	8.33%	6
	Total	100%	72

Q2.16 - Primary form of labor agreement you work under

#	Answer	%	Count
1	Union	13.89%	10
3	Other Labor Agreements	8.33%	6
2	Open Shop	77.78%	56
	Total	100%	72

Other Labor Agreements

Other Labor Agreements
nma
All the above

Q2.17 - Does your work typically utilize (Check all that apply)

#	Answer	%	Count
1	Advanced Work Packaging (AWP)	64.62%	42
2	Work Face Planning (WFP)	58.46%	38
3	Lean Construction	13.85%	9
4	Six Sigma	4.62%	3
5	Other	9.23%	6
6	Comments	3.08%	2
	Total	100%	65

Other

Other
building trades
Supts. plan the activities
Pre-outage or pre-job readiness

Comments

Comments
Company's need to get more involved in mentoring programs for Carft personnel
We are in the process of implementing Lean and Six Sigma into our organization.

Q2.18 - Please select the total cost of your current project (in millions)?

#	Answer	%	Count
1	0-15	16.67%	12
2	16-50	12.50%	9
3	51-250	26.39%	19
4	> 250	44.44%	32
	Total	100%	72

Q2.20 - PART A Please rate the following field impediments on basis of frequency on a scale of 1 to 5. Select the appropriate number below for each category using the following scale: 1 Never 2 Rarely 3 Sometimes 4 Often 5 Always

#	Question	1		2		3		4		5	
1	Waiting for material	6.25%	1	11.72%	15	27.01%	37	23.88%	16	40.00%	2
2	Waiting for equipment for example crane, forklift etc.	12.50%	2	21.88%	28	18.25%	25	22.39%	15	20.00%	1
3	Problem with power tools (availability, reliability, power sources, etc.)	43.75%	7	29.69%	38	15.33%	21	5.97%	4	20.00%	1
4	Quality problems in pre-fabricated items	0.00%	0	16.41%	21	22.63%	31	26.87%	18	0.00%	0
5	Scaffolding issues	37.50%	6	20.31%	26	16.79%	23	20.90%	14	20.00%	1
	Total	Total	16	Total	128	Total	137	Total	67	Total	5

Q2.21 - PART B Please rate the following planning/workforce impediments on basis of frequency on a scale of 1 to 5. Select the appropriate number below for each category using the following scale: 1 Never 2 Rarely 3 Sometimes 4 Often 5 Always

#	Question	1		2		3		4		5	
1	Errors in engineering drawings/ Inadequate engineering support	0.00%	0	8.99%	8	18.50%	32	16.67%	23	47.06%	8
2	Lack of effective preplanning	28.57%	2	20.22%	18	19.08%	33	12.32%	17	5.88%	1
3	Current skill level of workforce	0.00%	0	16.85%	15	15.03%	26	19.57%	27	11.76%	2
4	Field changes/ rework	0.00%	0	12.36%	11	17.34%	30	19.57%	27	11.76%	2
5	Manpower turnover	42.86%	3	21.35%	19	10.98%	19	19.57%	27	17.65%	3
6	Work Disruptions	28.57%	2	20.22%	18	19.08%	33	12.32%	17	5.88%	1
	Total	Total	7	Total	89	Total	173	Total	138	Total	17

Q2.22 - Please state other impediments if they are not listed in the above lists in the space given below.

Please state other impediments if they are not listed in the above lists in...
Lack of superintendents and foreman knowing how to develop a detailed plan and understand why it is so important. Safety Drugs
Clients Compressed schedules, reduction in cost, in most cases clients don't understand the means & methods of construction planning and scheduleing. More understanding of FEP Front End Planning for all projects regardless of size, budgets & schedules
permitting delays, weather delays.
Permitting procedures
Weather (lighting Storms) Often.
Interface with other General Contractor Construction equipment constraints Work ethics of the younger workforce Density in the work area where constructing
STOP PUTTING PEOPLE IN SUPERVISOR POSITIONS WHEN THEY HAVE NO KNOWLEDGE,NOT ONLY DOES THIS EFFECT THERE PRODUCTIVITY IT ALSO EFFECTS OTHER CRAFTS
Waiting on other crafts all the time!

Q2.23 - Please state suggestions that have to improve productivity in the space given below.

Please state suggestions that have to improve productivity in the space giv...
Employees caring about there jobs and taking pride in the work. It seems the two thing employees are worried about now days is pay day and quitting time
Train the superintendents and foreman on expectations. Don't just make someone a foreman and give no training.
More constructiablity with planning/sheduling, AFD, AFE, FEP, Engineering, PEP & CEP
proper training
Increased constructability efforts prior to mobilizing to begin construction Increase accuracy with surveying benchmarks (which decreases rework) Owner allowing Constructor to utilize the expertise they were hired to use
MAKE SURE PEOPLE ARE QUALIFYED FOR THE POSITION THEY HIRE IN FOR
We consistently under-estimate the impacts of late early deliverables from vendors and engineering. During the "Honeymoon" phase of a project no one wants to be the bad guy and call people out for not meeting their obligations, or we signed up a vendor with no teeth in their contract for their deliverables.
More leadership training.
Having equipment per crafts, example forklifts, and cranes.
Realize this industry is for adults not children. Stop babying these folks and require them to do what they hired on to do. You can be respectful and firm at the same time. This kinder more gentle approach does not work. Stop teaching the employees how to play the system and just make it simple, work hard or go home.
none

APPENDIX E- FOREMEN AND GENERAL FOREMEN SURVEY- DATA, ALL PROJECTS

Q1.1 - Please indicate your current role in the organization. Responses include; 1.Foreman 2.General Foreman 3.Superintendents and Managers with craft knowledge. Please select Option 3 if your role includes but is not limited to the following: Site Manager, Construction Manager, General Superintendent, Craft Superintendent, Project Manager, Project Director or equivalent positions

#	Answer	%	Count
1	1. Foreman	71.48%	822
2	2. General Foreman	28.52%	328
3	3. Superintendents and managers with craft knowledge	0.00%	0
	Total	100%	1150

Q3.7 - Please select your years of construction experience

#	Answer	%	Count
1	1-5	2.18%	7
2	6-10	9.35%	30
3	11-15	17.76%	57
4	16-20	23.68%	76
5	>21	47.04%	151
	Total	100%	321

Q3.8 - Please select your years of supervisory experience

#	Answer	%	Count
1	1-5	19.94%	63
2	6-10	28.80%	91
3	11-15	24.05%	76
4	16-20	15.51%	49
5	>20	11.71%	37
	Total	100%	316

Q3.12 - Are you a union member?

#	Answer	%	Count
1	Yes	35.40%	114
2	No	64.60%	208
	Total	100%	322

Q3.13 - Are you currently working on union project?

#	Answer	%	Count
1	Yes	36.02%	116
2	No	63.98%	206
	Total	100%	322

Q3.14 - Please select the total project cost of your current assignment (in millions)?

#	Answer	%	Count
1	0-15	17.37%	45
2	16-50	18.15%	47
3	> 51	64.48%	167
	Total	100%	259

Q3.15 - Does your work typically apply? (select all that apply)

#	Answer	%	Count
1	Advanced Work Packaging (AWP)	38.15%	140
2	Work Face Planning (WFP)	44.69%	164
3	Lean Construction	16.08%	59
4	Six Sigma	1.09%	4
	Total	100%	367

Q3.16 - Have you had training in any of the respective areas (select all that apply)

#	Answer	%	Count
1	Safety	82.83%	246
2	Quality Control	42.76%	127
3	Scheduling	46.80%	139
4	Estimating	30.64%	91
5	Supervisory Skills	90.91%	270
6	3D/BIM Model	10.10%	30
7	Effective Communication	60.27%	179
8	AWP/WFP	18.86%	56
9	Time Management	37.71%	112
10	Lean Construction	15.15%	45
11	Time Motion Studies	5.72%	17
	Total	100%	297

Q3.18 - Do you have clerical or administrative support?

#	Answer	%	Count
1	Yes	72.35%	225
2	No	27.65%	86
	Total	100%	311

Q3.19 - Do you have access to a computer?

#	Answer	%	Count
1	Yes	40.88%	130
2	No	59.12%	188
	Total	100%	318

Q3.4 - Select your craft

#	Answer	%	Count
1	Civil/Labor	12.35%	40
2	Iron Workers	10.49%	34
3	Mechanical/ Millwright	2.47%	8
4	Pipefitters	24.38%	79
12	Pipefitter Welders	1.54%	5
5	Electrical/ Instruments	14.81%	48
6	Insulation	0.00%	0
7	Carpenter/Scaffolder	6.17%	20
8	Boilermaker	4.94%	16
9	Sheet Metal Worker	0.00%	0
10	Paint	0.93%	3
11	Other	21.91%	71
	Total	100%	324

Q3.5 - Select your current phase of job

#	Answer	%	Count
1	Mobilization/ Pre-Construction	4.75%	14
2	Construction/ Bulk Construction	91.19%	269
3	Start-Up and Commissioning	4.07%	12
	Total	100%	295

Q3.6 - Select your shift

#	Answer	%	Count
1	8 Hour	1.85%	6
2	10 Hour	82.10%	266
3	12 Hour	16.05%	52
	Total	100%	324

3.2 - Based on your current work day, please select the number of minutes/hours that you spend each shift performing the indicated tasks.

Question	15-60 mins.		1.5-2 hrs.		2-4 hrs.		Total
Meetings – Client/Coordination/Scheduling/Look Ahead	49.53%	159	36.14%	116	14.33%	46	321
Plan/Prioritize Tasks & Fallback Work (Plan "B")	28.88%	93	53.73%	173	17.39%	56	322
Safety Related Activities – Meetings/Job Hazards Analysis (JHAs) Development/Inspections/Action Items/Sign/Review Field Level Hazard Assessments (FLHAs)	12.69%	41	74.92%	242	12.38%	40	323
Constraint Management – Ensure Foreman has all Crane support/crane/scaffold/material/equipment	47.92%	150	38.66%	121	13.42%	42	313
Follow up with foreman & Crews Throughout Day – Work Area Reviews/Productivity Check in Field	18.32%	59	47.83%	154	33.85%	109	322
Work Package Development – Model Review/Field Installation Work Package (FIWP) Review/FIWP Schedule/Close-Out FIWPs	49.68%	153	45.78%	141	4.55%	14	308
Communicate with Field Engineers – Develop Estimates for Extra Work/Request For Informations (RFIs)	33.65%	105	53.21%	166	13.14%	41	312
Complete Progress/Timesheets/Forecasts/Review Installed Quantities/Cost Codes	12.93%	41	70.03%	222	17.03%	54	317

Q4.7 - Please select your years of construction experience

#	Answer	%	Count
1	1-5	4.76%	38
2	6-10	18.52%	148
3	11-15	18.90%	151
4	16-20	22.28%	178
5	>21	35.54%	284
	Total	100%	799

Q4.8 - Please select your years of supervisory experience

#	Answer	%	Count
1	1-5	41.67%	330
2	6-10	26.64%	211
3	11-15	15.91%	126
4	16-20	8.08%	64
5	>21	7.70%	61
	Total	100%	792

Q4.9 - Please select the appropriate Geographic region of work

#	Answer	%	Count
1	1. Foreman	71.48%	822
2	2. General Foreman	28.52%	328
3	3. Superintendents and managers with craft knowledge	0.00%	0
	Total	100%	1150

Q4.10 - Please indicate your type of work

#	Answer	%	Count
1	Heavy Industrial	93.90%	723
2	Light Industrial	6.10%	47
	Total	100%	770

Q4.11 - Circle the 'typical' size of crew you are supervising?

#	Answer	%	Count
1	1-5	17.39%	136
3	6-10	56.39%	441
5	11-15	17.26%	135
2	16-20	4.48%	35
4	>21	4.48%	35
	Total	100%	782

Q4.12 - Are you a union member?

#	Answer	%	Count
1	Yes	36.94%	297
2	No	63.06%	507
	Total	100%	804

Q4.13 - Are you currently working on union project?

#	Answer	%	Count
1	Yes	35.74%	287
2	No	64.26%	516
	Total	100%	803

Q4.19 - Does your work typically apply? (select all that apply)

#	Answer	%	Count
1	Advanced Work Packaging (AWP)	37.80%	299
2	Work Face Planning (WFP)	42.60%	337
3	Lean Construction	18.08%	143
4	Six Sigma	1.52%	12
	Total	100%	791

Q4.15 - Have you had training in any of the respective areas (select all that apply)

#	Answer	%	Count
1	Safety	75.63%	540
2	Quality Control	36.83%	263
3	Scheduling	29.69%	212
4	Estimating	17.93%	128
5	Supervisory Skills	85.71%	612
6	3D/BIM Model	4.48%	32
7	Effective Communication	47.76%	341
8	AWP/WFP	15.13%	108
9	Time Management	27.17%	194
10	Lean Construction	14.71%	105
11	Time Motion Studies	4.62%	33
	Total	100%	714

Q4.17 - Do you have clerical or administrative support?

#	Answer	%	Count
1	Yes	67.05%	519
2	No	32.95%	255
	Total	100%	774

Q4.18 - Do you have access to a computer?

#	Answer	%	Count
1	Yes	32.83%	260
2	No	67.17%	532
	Total	100%	792

Q4.4 - Select your craft

#	Answer	%	Count
1	Civil/Labor	13.18%	106
2	Iron Workers	13.56%	109
3	Mechanical/ Millwright	2.86%	23
12	Pipefitter	24.38%	196
4	Pipefitter Welders	3.11%	25
5	Electrical/ Instruments	12.56%	101
6	Insulation	1.12%	9
7	Carpenter/Scaffolder	9.20%	74
8	Boilermaker	6.09%	49
9	Sheet Metal Worker	0.62%	5
10	Paint	0.25%	2
11	Other	13.06%	105
	Total	100%	804

Q4.5 - Select your current phase of job

#	Answer	%	Count
1	Mobilization/ Pre-Construction	7.64%	54
2	Construction/ Bulk Construction	89.82%	635
3	Start-Up and Commissioning	2.55%	18
	Total	100%	707

Q4.6 - Select your shift

#	Answer	%	Count
1	8 Hour	2.24%	18
2	10 Hour	84.29%	676
3	12 Hour	13.47%	108
	Total	100%	802

Q4.2 - Based on your current work day, please select the number of minutes/hours that you spend each shift performing the indicated tasks.

Question	15-60 mins.		1.5-2 hrs.		2-4 hrs.		Total
Meetings – Client/Coordination/Scheduling/Look Ahead	68.12%	547	26.53%	213	5.35%	43	803
Plan/Prioritize Tasks & Fallback Work (Plan "B")	50.38%	400	43.70%	347	5.92%	47	794
Safety Related Activities – Meetings/Job Hazards Analysis (JHAs) Development/Inspections/Action Items/Sign/Review	19.51%	158	72.35%	586	8.15%	66	810
Complete Paperwork	29.43%	239	52.59%	427	17.98%	146	812
Coordinate with other crews/support	2.37%	19	47.13%	378	50.50%	405	802
Supervise/ Motivate/ Execute	24.16%	194	36.49%	293	39.35%	316	803
Plan for Future Work	33.67%	267	49.94%	396	16.39%	130	793
Work on Tools with Crew	40.77%	327	33.79%	271	25.44%	204	802
Receive/ Check/ Verify Materials in Area	5.36%	43	39.65%	318	54.99%	441	802
Move Crews to Contingency Work	6.78%	54	50.25%	400	42.96%	342	796

Q3.21 - PART A Please rate the following field impediments on basis of frequency on a scale of 1 to 5. Select the appropriate number below for each category using the following scale: 1 Never 2 Rarely 3 Sometimes 4 Often 5 Always

#	Question	1		2		3		4		5		Total
1	Waiting for material	8.70%	28	19.88%	64	33.85%	109	22.36%	72	15.22%	49	322
2	Waiting for equipment for example crane, forklift etc.	12.15%	39	27.73%	89	34.58%	111	17.45%	56	8.10%	26	321
3	Problems with power tools (availability, reliability, power sources etc.)	24.84%	79	34.59%	110	27.99%	89	9.43%	30	3.14%	10	318
4	Quality problems in pre-fabricated items	23.25%	73	29.62%	93	27.71%	87	13.69%	43	5.73%	18	314
5	Scaffolding issues	23.81%	75	25.40%	80	28.89%	91	13.65%	43	8.25%	26	315

Q3.22 - PART B Please rate the following Planning/ workforce impediments on basis of frequency on a scale of 1 to 5. Select the appropriate number below for each category using the following scale: 1 Never 2 Rarely 3 Sometimes 4 Often 5 Always

#	Question	1		2		3		4		5	
1	Errors in engineering drawings/ inadequate engineering support	20.89%	47	15.40%	87	15.16%	99	16.92%	56	18.46%	24
2	Lack of effective preplanning	21.78%	49	16.28%	92	15.62%	102	16.62%	55	16.92%	22
3	Current skill level of workforce	15.56%	35	13.27%	75	17.76%	116	21.45%	71	17.69%	23
4	Filed changes/ rework	11.56%	26	14.69%	83	17.92%	117	20.85%	69	17.69%	23
5	Manpower turnover	17.78%	40	22.30%	126	14.85%	97	9.97%	33	15.38%	20
6	Work Disruptions	12.44%	28	18.05%	102	18.68%	122	14.20%	47	13.85%	18
	Total	Total	225	Total	565	Total	653	Total	331	Total	130

Q4.14 - What is the total project cost of your current assignment (in millions)?

#	Answer	%	Count
1	0-15	13.83%	83
2	16-50	18.33%	110
3	> 51	67.83%	407
	Total	100%	600

Q4.21 - PART A Please rate the following field impediments on basis of frequency on a scale of 1 to 5. Select the appropriate number below for each category using the following scale: 1 Never 2 Rarely 3 Sometimes 4 Often 5 Always

#	Question	1		2		3		4		5	
1	Waiting for material	10.12%	74	14.36%	161	23.81%	279	29.16%	184	31.18%	106
2	Waiting for equipment for example crane, forklift etc.	11.63%	85	17.04%	191	23.38%	274	27.58%	174	24.41%	83
3	Problem with power tools (availability, reliability, power sources, etc.)	27.36%	200	26.23%	294	16.47%	193	13.31%	84	7.94%	27
4	Quality problems in pre-fabricated items	24.49%	179	23.37%	262	19.28%	226	12.68%	80	12.65%	43
5	Scaffolding issues	26.40%	193	19.00%	213	17.06%	200	17.27%	109	23.82%	81
	Total	Total	731	Total	1121	Total	1172	Total	631	Total	340

Q3.26 - Select the appropriate number below for observed skill level for each category for FOREMEN using the following scale: 1 Inadequate/ quite low 2 Fair/ needs improvement 3 Adequate/ neither low nor high 4 Good- Above average/ slightly high 5 Very Good/ quite high 6 Excellent/ extremely high

#	Question	1		2		3		4		5		6		Total
1	General Construction Knowledge	1.28%	4	3.19%	10	17.25%	54	35.78%	112	32.59%	102	9.90%	31	313
2	Trade Specific Knowledge	0.97%	3	3.55%	11	17.42%	54	28.71%	89	36.13%	112	13.23%	41	310
3	Verbal Communication	1.29%	4	4.19%	13	24.52%	76	34.84%	108	28.39%	88	6.77%	21	310
4	Written Communication	2.27%	7	6.17%	19	30.19%	93	32.47%	100	23.38%	72	5.52%	17	308
5	Pre Planning	2.29%	7	8.17%	25	23.53%	72	30.72%	94	29.08%	89	6.21%	19	306
6	Problem Solving	2.58%	8	8.39%	26	18.39%	57	28.71%	89	31.61%	98	10.32%	32	310
7	Ethical (Trustworthy, fair, empathetic, and even handed)	1.29%	4	3.56%	11	17.80%	55	23.95%	74	35.28%	109	18.12%	56	309
8	People Management (Task assignments, delegating, conflict resolution, discipline)	1.60%	5	5.77%	18	21.15%	66	31.09%	97	34.62%	108	5.77%	18	312
9	Leadership	1.61%	5	3.55%	11	14.84%	46	32.26%	100	33.55%	104	14.19%	44	310
10	Proactive and Goal Driven	1.29%	4	6.43%	20	13.83%	43	30.23%	94	32.48%	101	15.76%	49	311

Q4.22 - PART B Please rate the following Planning/ workforce impediments on basis of frequency on a scale of 1 to 5. Select the appropriate number below for each category using the following scale: 1 Never 2 Rarely 3 Sometimes 4 Often 5 Always

#	Question	1		2		3		4		5	
1	Errors in engineering drawings/ inadequate engineering support	21.34%	137	17.71%	257	14.74%	241	14.40%	104	17.65%	57
2	Lack of effective preplanning	19.63%	126	17.78%	258	15.66%	256	13.85%	100	18.27%	59
3	Current skill level of workforce	15.11%	97	14.33%	208	16.70%	273	20.50%	148	20.12%	65
4	Filed changes/ rework	11.21%	72	15.78%	229	16.82%	275	20.36%	147	21.98%	71
5	Manpower turnover	20.72%	133	17.78%	258	15.84%	259	15.24%	110	10.84%	35
6	Work Disruptions	11.99%	77	16.61%	241	20.24%	331	15.65%	113	11.15%	36
	Total	Total	642	Total	1451	Total	1635	Total	722	Total	323

APPENDIX F- INTERVIEW QUESTIONNAIRE- FOREMEN AND GENERAL FOREMEN

FOREMAN INTERVIEW GUIDE

GENERAL INFORMATION

1) What is your trade and how long have you been practicing it?
2) I would like to know how long have you been in this company and your years of experience in this role.
3) Please tell me about the trainings/coaching that helped you to adapt to your new role.
4) Please tell me about your typical work day.
    a. Do you come in early to preplan, if so are you paid for it?
    b. Elaborate on timeline/sequence of important tasks.
    c. How do you manage your time?
    d. What activities would you like to spend more or less time on and why?
5) How satisfied are you with the skill level of your crew?
6) Are the work packages you receive from your GFs/planners clear and complete? Elaborate on what is typically included. Elaborate on what you find most helpful or most needed/missing.

PLAN

7) How do you organize and assign work to your different crews?

RECOVER

8) How frequently do you work on something other than planned? “go to plan B”
9) Tell me the last time you were forced to work on some other work area than planned? What triggered this change? Was plan B ready for execution? (materials, scaffolding, etc)
    a. How did you communicate to your supervisors and what options did you evaluate? (was there communication amongst trades?)
    b. How did you encourage your crew to deal with this path change?

GENERAL FOREMAN INTERVIEW GUIDE

GENERAL INFORMATION

1) What is your trade and how long have you been practicing it?
2) I would like to know how long have you been in this company and your years of experience in this role.
3) Please tell me about your typical work day.
    a. Do you come in early to preplan, if so are you paid for it?
    b. Elaborate on timeline/sequence of important tasks.
    c. How do you manage your time?
    d. What activities would you like to spend more or less time on and why?
4) Tell us about your perception regarding the skill levels of foremen- Increasing, decreasing or about the same.
5) What are the challenges for you to recruit good foremen?
6) Elaborate on what is typically included in a work package you distribute to your foremen. What part do you play in developing the work packages? Who assists you in preparing them for your foremen?

PRIORITIZE

7) How do you plan for the work that needs to be accomplished during the week?
    a. How do you make sure that your work packages are ready to be given to your foremen?
8) How far out in the future do you plan for your work? (*1 week, 3 week, 90 days)

MANAGE

9) How do you validate your team's progress with respect to safety, quality and performance?

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